3.0 DATA SUMMARY

Sampling was conducted in 2003 and 2004 under the Guadalupe River Watershed Mercury TMDL project to provide additional data for use in development of the TMDL. The Synoptic Survey provided an initial overview of the creeks and reservoirs; water and sediment sampling was conducted at 24 locations on July 30-31, 2003. Additional data were obtained between February 26 and April 23, 2004 to assess the magnitude of mercury loading to the Guadalupe Watershed during the wet season when water samples were collected at 55 locations and sediment samples were collected from nine locations. Detailed dry season sampling was conducted at Almaden and Guadalupe Reservoirs from May 11 to August 31, 2004 to estimate methylmercury production and transport from the reservoirs to the downstream creeks. Fish sampling was also conducted during the dry-season sampling to measure fish-tissue mercury concentrations throughout the watershed. This section summarizes the data from these sampling efforts. Detailed descriptions of the results are provided in “Technical Memorandum 5.3.2 Data Collection Report” (Tetra Tech, 2005a). Historical data are also summarized in that report.

3.1 WET SEASON CREEKS AND RIVER SAMPLING

3.1.1 UPPER WATERSHED CREEKS

Three sampling events were conducted in the Almaden, Calero, Guadalupe, and Lexington Reservoir watersheds between March 2 and April 20, 2004. The sample locations are shown on a map of the upper Guadalupe River watershed (Figure 3-1). Measurements were made of suspended sediments, flow rates at ungauged locations, total and dissolved mercury, and methylmercury in each creek upstream of where it enters a reservoir, the reservoir outlets, and the Almaden-Calero Canal. The reservoir outlets and the Almaden-Calero Canal were also analyzed for dissolved methylmercury. The daily rainfall at the watershed gauges during the sampling events is shown in Figure 3-2.

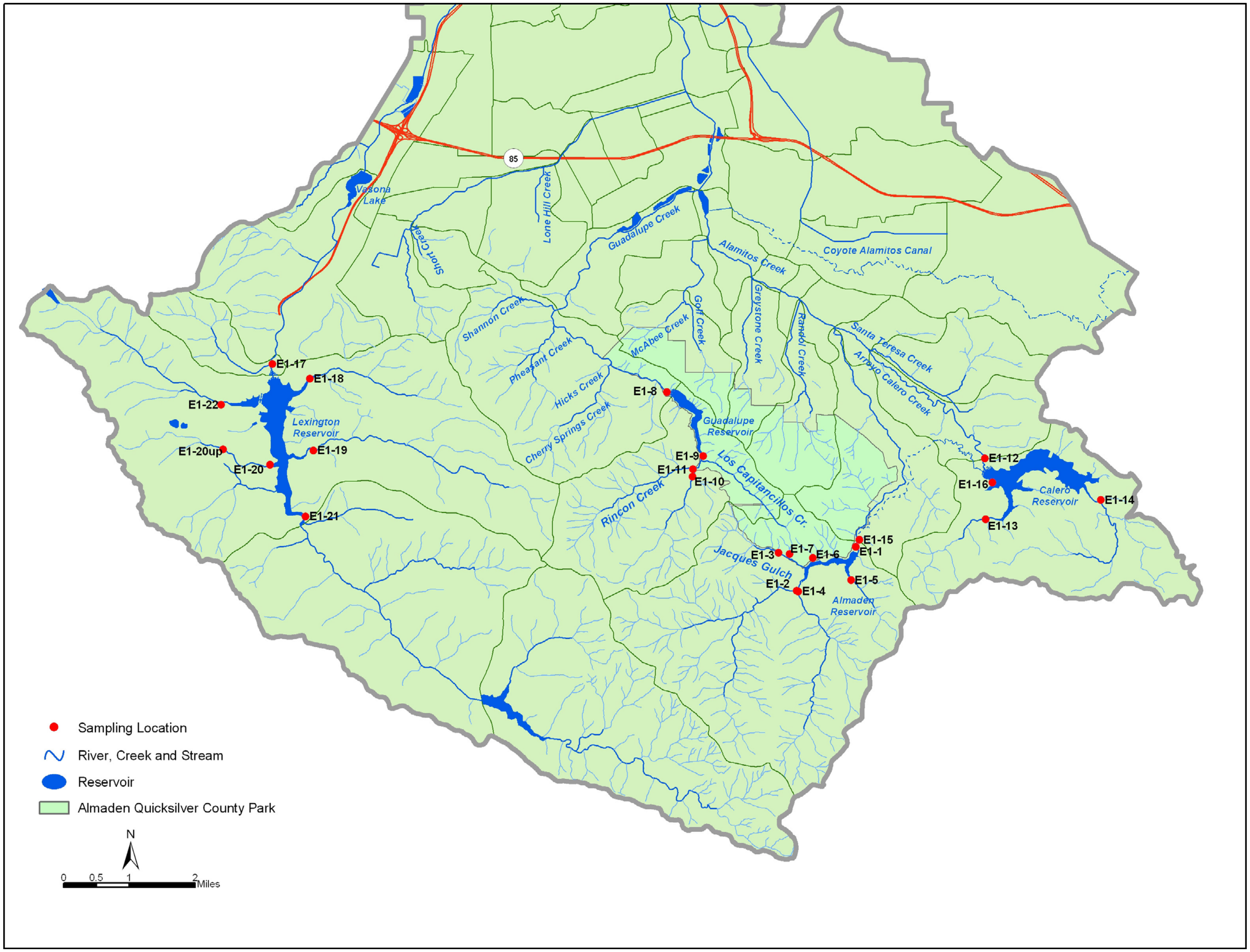


Figure 3-1. Sampling Locations for Upper Watershed Creeks and Reservoir Outlets

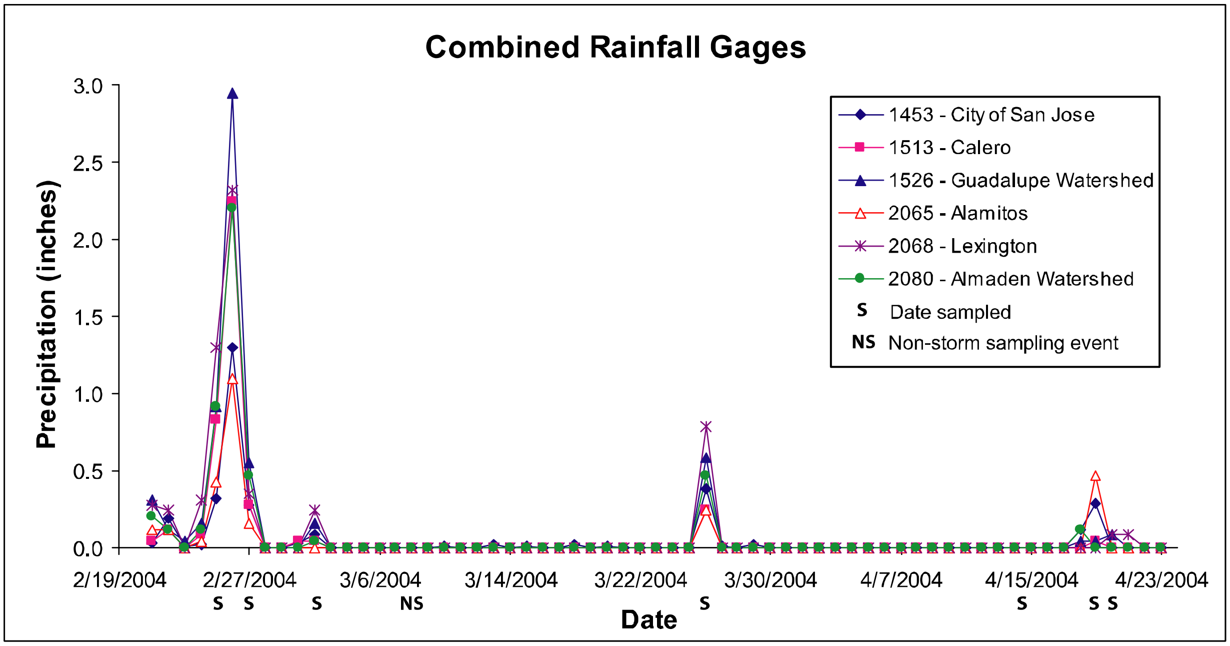


Figure 3-2. Rainfall measured at selected gages during the sampling period for this study ("S" indicates date sampled. "NS" indicates date when sampled on non-storm day.)

The flows for the tributaries and outlets for the three sampling events are provided in Table 3-1. The chemical data are presented in the Data Collection Report (Tetra Tech, 2005a). Each reservoir watershed had one dominant inflow, therefore both flow and mercury concentrations are needed for load estimates. For Calero Reservoir, the dominant inflow for these sampling events was the Almaden-Calero Canal, although releases to the canal are variable. The wet season data are summarized below:

- **Suspended solids.** The suspended solids concentrations ranged from 0.4 mg/L in the Mine Hill tributary to Jacques Gulch, a tributary to Almaden Reservoir, to 54 mg/L in Lyndon Canyon, a tributary to Lexington Reservoir. The suspended solids in the reservoir outlets ranged from 6.3 mg/L (Calero – 4/14/04) to 97.6 mg/L (Lexington – 3/2/04). The suspended solids in the canal varied from 7.7 mg/L to 17.9 mg/L.

- **Total Mercury.** The total mercury concentrations in the tributary samples ranged from 1.9 ng/L in Briggs Creek at Bear Creek Road, a tributary to Lexington Reservoir, to 82 ng/L, in the West tributary from Mine Hill to Almaden Reservoir. The total mercury concentrations in the reservoir outlet samples ranged from 5.9 ng/L (Lexington – 4/20/2004) to 77.4 ng/L (Guadalupe – 3/2/2004). The total mercury in the canal samples ranged from 24.7 ng/L to 90.5 ng/L. As seen in Figure 3-3, the tributaries to Guadalupe and Almaden Reservoirs influenced by mining had higher total mercury concentrations (13.4 ng/L to 82.2 ng/L) than the other tributaries to those reservoirs (2.0 ng/l to 8.7 ng/L (Jacques Gulch above the Mine Hill tributary)). The total mercury in the Lexington tributaries ranged from

1.9 ng/L (Briggs Creek) to 13.5 ng/L (Lyndon Canyon). The dissolved fraction was variable, but lowest in the Lexington Reservoir tributaries.

Table 3-1.
Flows for Reservoir Tributaries and Outlets, Wet Season Sampling 2004

Station No.	Station Name	Date	Time	Gauged Flow, cfs	Est Flow, cfs
E1-1	Almaden Reservoir Outlet	3/2/2004	12:00	30.2	
E1-1	Almaden Reservoir Outlet	3/8/2004	14:00	21.4	
E1-1	Almaden Reservoir Outlet	4/14/2004	10:10	5.4	
E1-2	Herbert Creek	3/2/2004	15:10		43.4
E1-3	Jacques Gulch above Mine Hill Tributary	3/2/2004	15:00		0.75
E1-3A	Jacques Gulch above Mine Hill Tributary	3/26/2004	9:30		0.91
E1-4	Barret Canyon	3/2/2004	15:35		31.2
E1-5	Larrabee Gulch	3/2/2004	13:35		1.50
E1-6	W. Tributary from Mine Hill to Almaden Reservoir	3/2/2004	14:30		0.03
E1-7	Mine Hill Tributary to Jacques Gulch	3/2/2004	15:30		0.4
E1-7	Mine Hill Tributary to Jacques Gulch	3/26/2004	10:31		0.5
E1-8	Guadalupe Reservoir Outlet	3/2/2004	13:35	5.2	
E1-8	Guadalupe Reservoir Outlet	3/8/2004	14:50	5.2	
E1-8	Guadalupe Reservoir Outlet	4/14/2004	9:18	6.25	
E1-9	N. Los Capitancillos Creek	3/26/2004	9:00		1.58
E1-9A	N. Los Capitancillos Creek	3/3/2004	9:55		0.17
E1-10	Upper Guadalupe Creek	3/2/2004	14:15		3.76
E1-11	Rincon Creek	3/2/2004	13:55		4.94
E1-12	Calero Reservoir Outlet	3/2/2004	9:55	3	
E1-12	Calero Reservoir Outlet	3/8/2004	13:10	2.9	
E1-12	Calero Reservoir Outlet	4/14/2004	9:15	3	
E1-13	Cherry Canyon	3/2/2004	9:25		1.13
E1-14	Pine Tree Canyon	3/2/2004	10:30		1.89
E1-15	Inlet to Almaden-Calero Canal	3/2/2004	11:30	NA	
E1-15	Inlet to Almaden-Calero Canal	3/3/2004	11:03	NA	
E1-16	Outlet to Almaden-Calero Canal	3/2/2004	8:25	3.8	
E1-16	Outlet to Almaden-Calero Canal	3/3/2004	11:34	59.4	
E1-17	Lexington Reservoir Outlet	3/2/2004	9:10	6.1	
E1-17	Lexington Reservoir Outlet	3/8/2004	9:45	2.7	
E1-17	Lexington Reservoir Outlet	4/20/2004	7:30	31.8	
E1-18	Limekiln Canyon	3/2/2004	9:45		2.4
E1-19	Soda Spring	3/2/2004	10:15		10.5
E1-20	Briggs Creek at CDF	3/2/2004	12:25		<0.1*
E1-20up	Briggs Creek at Bear Creek Road	3/8/2004	8:30		1.88
E1-21	Upper Los Gatos Creek	3/2/2004	11:50		45.6
E1-22	Lyndon Canyon	3/2/2004	11:00		13.2

*Considered to be affected by backwater from reservoir, so sampled upstream.

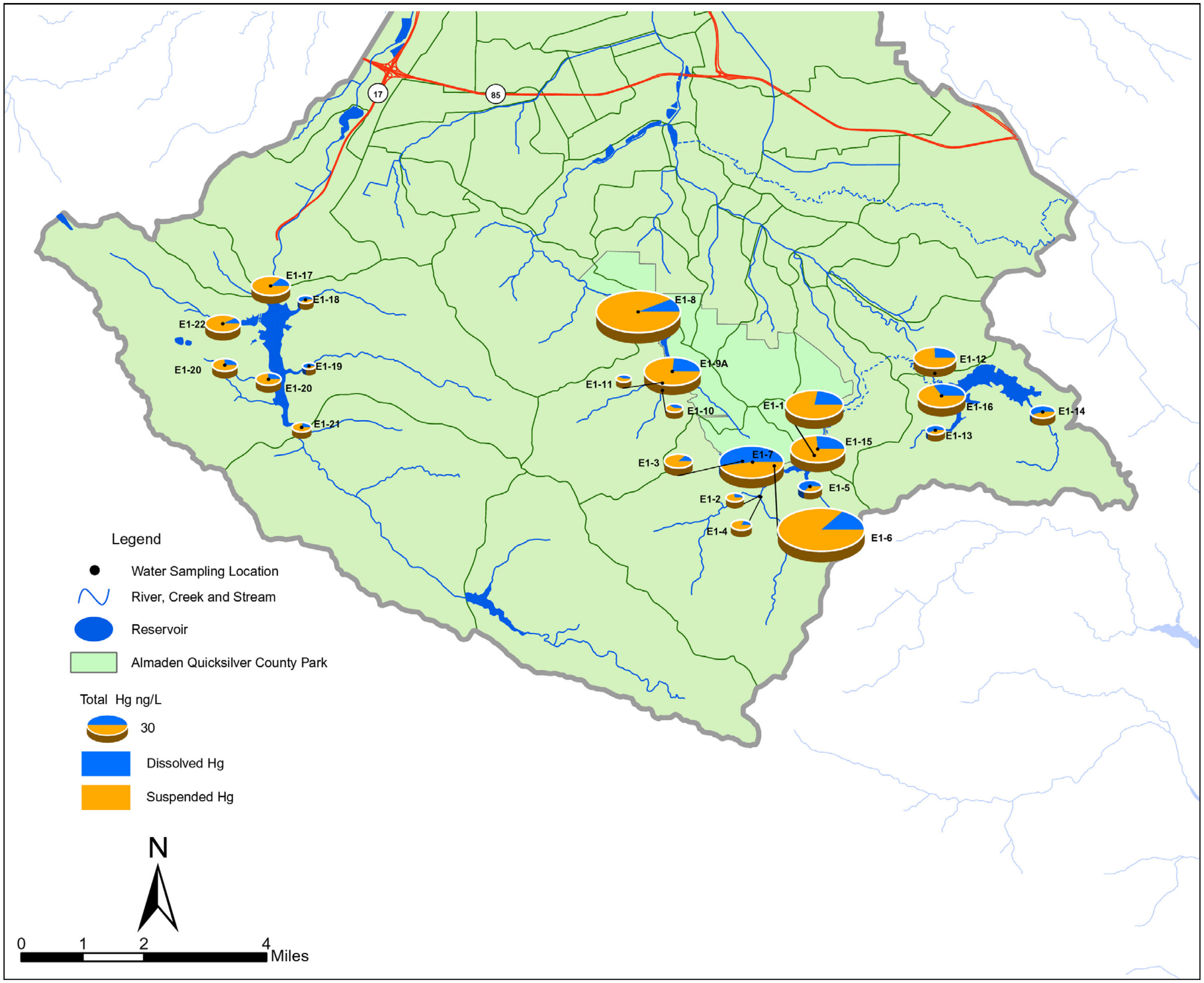


Figure 3-3. Total and dissolved mercury in reservoir watershed water samples.

- **Methylmercury**. The methylmercury in the tributaries ranged from 0.01 ng/L in Briggs Creek at Bear Creek Road, a tributary to Lexington Reservoir, to 0.20 ng/L in N. Los Capitancillos Creek, a tributary to Guadalupe Reservoir. The reservoir outlets had a wider range of methylmercury concentrations (0.06 ng/L in Lexington to 0.70 ng/L in Guadalupe). Methylmercury concentrations in the canal ranged from 0.22 ng/L to 0.29 ng/L. The reservoir outlets from Almaden and Guadalupe Reservoirs had higher methylmercury (0.23 ng/L to 0.70 ng/L) than the tributaries (0.03 ng/L to 0.20 ng/L). Methylmercury in the tributaries to Lexington ranged from 0.01 ng/L to 0.14 ng/L. The dissolved fraction was significant, even when the methylmercury concentrations were low.

- **Mercury in Particulate Fraction.** The mercury content on the suspended particulates was calculated from the total and dissolved mercury concentrations and the suspended solids, as follows:

$$P = (T - D)/SS \times 1000$$

where

P = particulate fraction of mercury in ng/g
T = total mercury in ng/L
D = dissolved mercury in ng/L
SS = suspended solids in mg/L.

The results are expressed on a mass basis, i.e., ng of mercury per gram of suspended matter. The mercury content in the suspended fraction can indicate the mercury concentration of future sediment if it settles at a downstream location.

The Guadalupe Workgroup asked whether the mercury concentration of the particulates was less than 0.2 mg/kg, the proposed annual median suspended sediment target for the San Francisco Bay TMDL. While the samples from the tributaries to Lexington Reservoir had low mercury concentrations in the particulate fraction (0.11 to 0.58 mg/kg), only one tributary, Briggs Creek, had particulate mercury concentrations less than 0.2 mg/kg. In comparison, the samples from mine-influenced tributaries had mercury concentrations in the particulate fractions ranging from 0.63 mg/kg to 61.26 mg/kg. The particulate-fraction concentrations measured in other tributaries from the upper watershed were also greater than 0.2 mg/kg. The outlet from Lexington Reservoir was the only outlet with particulate mercury concentrations less than 0.2 mg/kg (0.14 mg/kg to 0.19 mg/kg).

The highest total mercury concentrations measured were found in the three tributaries draining the mining area:

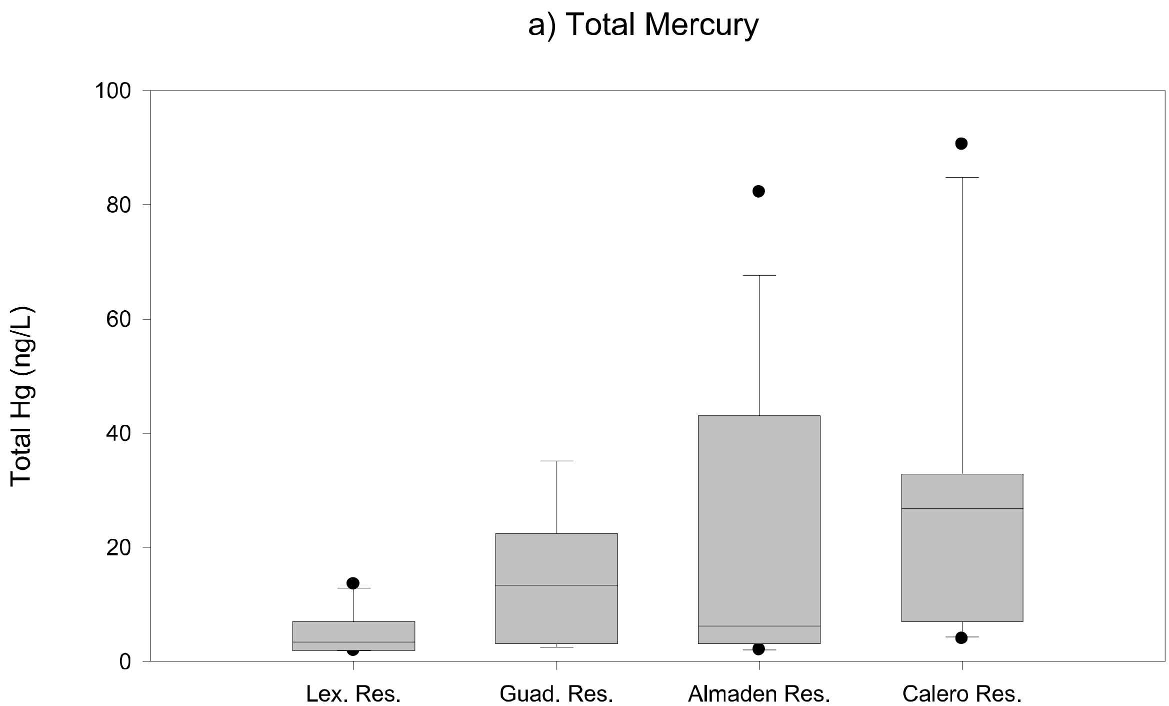
Mine Hill tributary to Jacques Gulch then Almaden – 42.2 ng/L to 45.6 ng/L
West tributary to Almaden Reservoir – 82.2 ng/L
N. Los Capitancillos Creek to Guadalupe Reservoir – 13.4 ng/L to 35.1 ng/L.

Total mercury concentrations in the other creeks ranged from 2.0 ng/L in Jacques Gulch above the Mine Hill tributary to 13.5 ng/L in Lyndon Canyon. Lyndon Canyon had suspended solids of 54.1 mg/L; the higher total mercury concentration is due to the higher suspended solids; the particulate mercury was low (0.23 mg/kg). The dissolved mercury was also highest in the three mining area creeks. The highest methylmercury concentration (0.29 ng/L) was in the outlet of the Almaden-Calero Canal, compared to 0.06 to 0.20 ng/L in the above mining area creeks.

The concentrations of the total and methylmercury in the upper watershed creeks are compared in Figure 3-4. The tributaries to Lexington Reservoir had the lowest concentrations of both mercury species, while the Almaden-Calero Canal had the highest maximum concentrations of both species. The canal sample with the highest total mercury had moderate suspended solids (17.9 mg/L) and elevated particulate mercury (4.7 mg/kg). The next highest concentration was from the west tributary to Almaden Reservoir, which had low suspended solids (2.4 mg/L) but high particulate mercury (29.56 mg/kg).

3.1.2 Creeks Below Impoundments Affected by Mercury Mining

Runoff from former mining areas and in-stream processes are contributing mercury to Guadalupe, Alamitos and Calero Creeks, three of the major tributaries to the Guadalupe River. Three sampling events were conducted between March 8 and April 23, 2004 at 18 sites on Alamitos, Guadalupe, and Calero Creeks and their tributaries. The locations were selected to distinguish the mercury load coming from tributaries from erosion and sediment resuspension. The sampling locations are shown on a map of the upper Guadalupe River watershed on Figure 3-5. Measurements were made of suspended sediments, flow rates at ungauged locations, total and dissolved mercury, and methylmercury at each location. Dissolved methylmercury was measured at five of the locations, two on Guadalupe Creek and three on Alamitos Creek. Results were used to compare tributary loads to the major creeks and the internally-generated loads from bank erosion and sediment resuspension within the creeks.



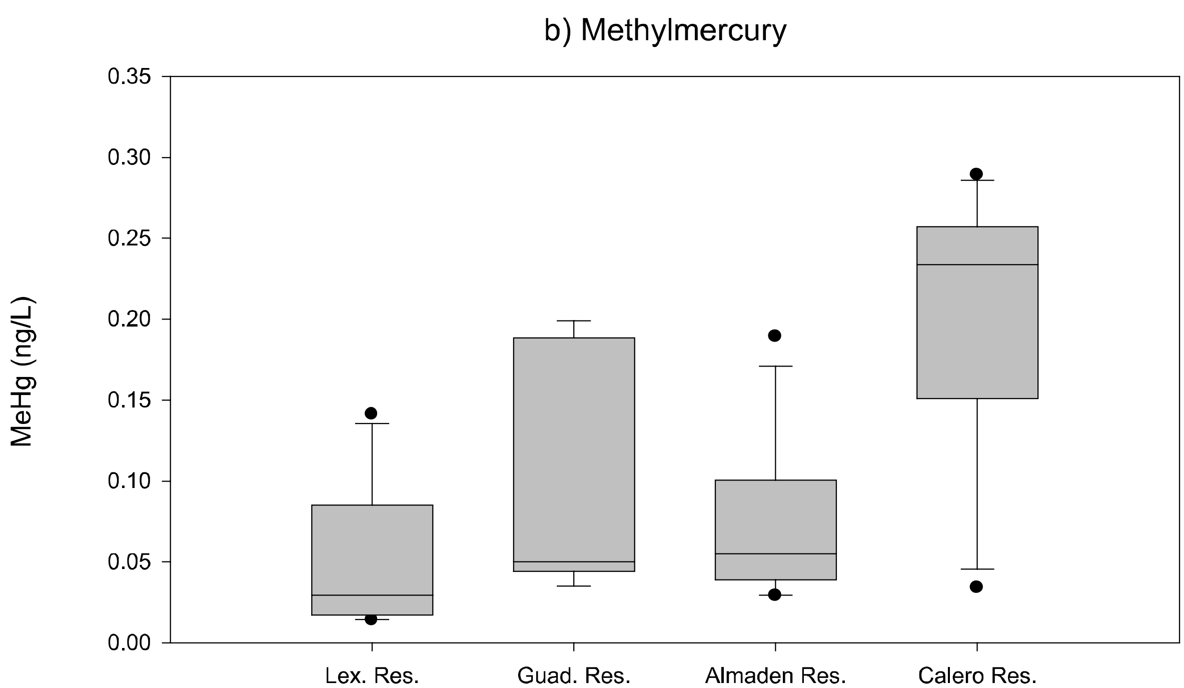


Figure 3-4. Box Plots for reservoir tributaries a) total mercury and b) methylmercury

(Box plots show the 25th and 75th percentiles as the top and bottom of the box; the median is the line inside the box. The line below the box is the 10th percentile and the line above the box is the 90th percentile. The black circles above or below the box show values outside of the 10th or 90th percentiles.)

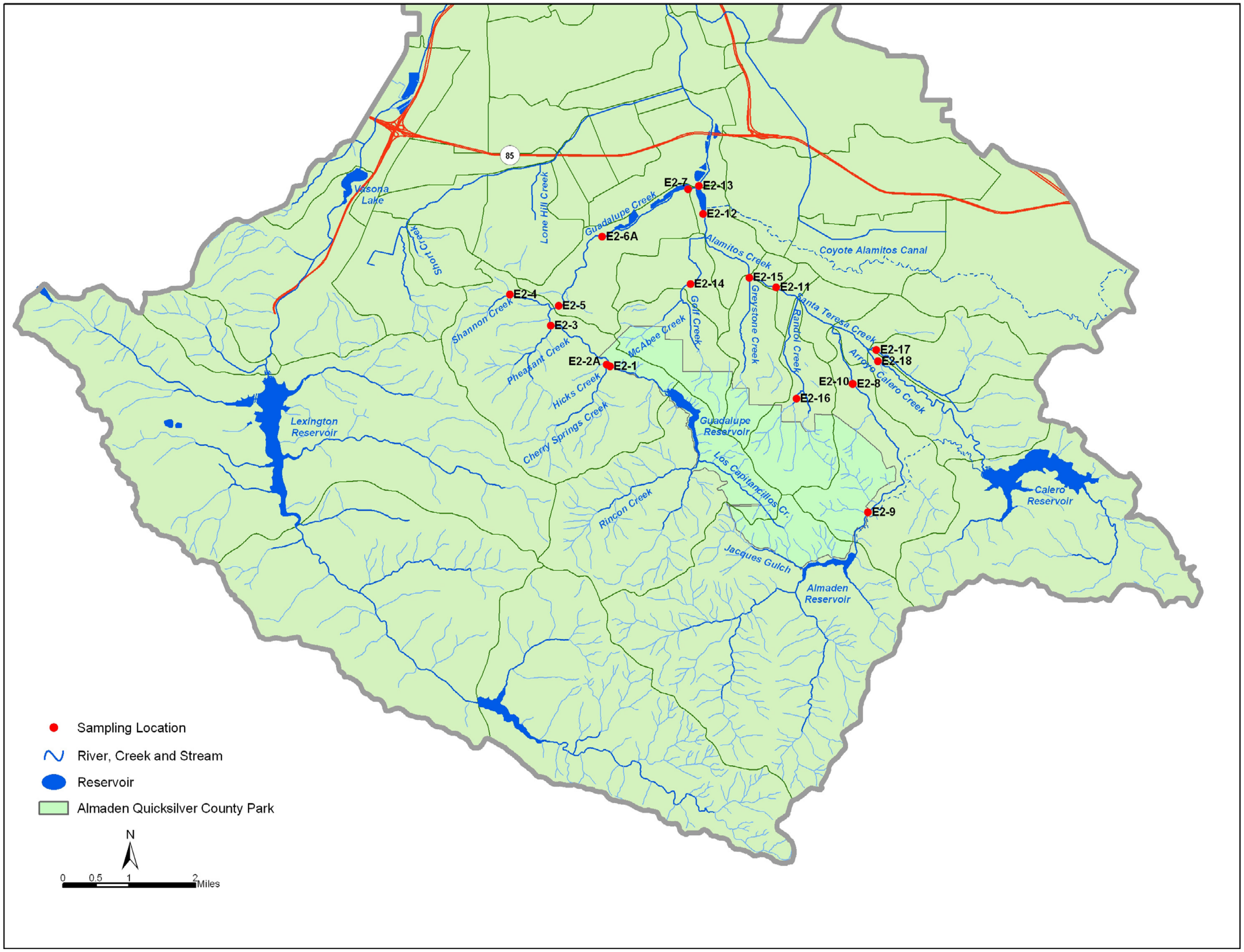


Figure 3-5. Sampling Locations of Creeks, Affected by Mining Below Impoundments

Flows at the sampling locations are provided in Table 3-2. Water quality and mercury results are presented in the Data Collection Report (Tetra Tech, 2005a). There was limited rainfall at the time of sampling in this part of the watershed, so low flows were sampled.

Table 3-2.
Flow Measurements for Element 2 Sampling Locations, Wet Season 2004

Station No.	Station Name	Date	Time	Est Flow, cfs
E2-1	Guadalupe Creek upstream of Cherry Springs Creek	4/14/2004	8:59	6.08
E2-2A	Cherry Springs Creek	4/14/2004	8:48	3.61
E2-2B	Cherry Springs Creek (replicate)	4/14/2004	8:48	rep
E2-3	Pheasant Creek	4/14/2004	8:22	0.75
E2-4	Shannon Creek	4/14/2004	7:58	0.2
E2-5	Guadalupe Creek @ Old Gauge	4/14/2004	7:37	12.6
E2-5	Guadalupe Creek @ Old Gauge	4/20/2004	10:59	17.6
E2-6	Guadalupe Creek below Masson Dam	4/20/2004	7:45	NA
E2-6A	Guadalupe Creek below Masson Dam	4/19/2004	12:30	NA
E2-6B	Guadalupe Creek below Masson Dam (replicate)	4/19/2004	12:30	rep
E2-7	Guadalupe Creek above Almaden Expressway	3/8/2004	11:50	7.05
E2-7	Guadalupe Creek above Almaden Expwy	4/19/2004	0.45	1.01
E2-7A	Guadalupe River above Almaden Expwy	4/20/2004	9:49	2.22
E2-7B	Guadalupe River above Almaden Expwy (replicate)	4/20/2004	9:49	rep
E2-8	Deep Gulch at previously-used site	3/26/2004	11:00	0.21
E2-9	Alamitos Creek @ Almaden Road Bridge near AQC Park	4/20/2004	13:30	4.54
E2-10	Alamitos Creek @ Harry Road	4/19/2004	14:29	13.36
E2-10	Alamitos Creek @ Harry Road	4/20/2004	12:50	2.6
E2-11	Alamitos Creek at Greystone Lane	4/19/2004	13:15	7.06
E2-11	Alamitos Creek @ Greystone Lane	4/20/2004	12:20	2.16
E2-12	Alamitos Creek above Almaden Lake	3/8/2004	12:25	31.68
E2-12	Alamitos Creek above Almaden Lake	4/19/2004	11:50	8.57
E2-12	Alamitos Creek above Almaden Lake	4/20/2004	10:31	11.78
E2-13	Almaden Lake Outlet	4/19/2004	11:27	15.7
E2-13	Almaden Lake Outlet	4/20/2004	10:09	14.96
E2-14	Golf Creek upstream of Alamitos Cr (below Camden Ave)	4/23/2004	1:00	NA
E2-15	Greystone Creek upstream of Alamitos Creek	4/19/2004	13:35	1.31
E2-16	Randol Creek upstream of Alamitos Creek	4/19/2004	14:00	0.2
E2-17	Santa Teresa Creek upstream of Calero Creek	4/14/2004	8:45	0.51
E2-18	Calero Creek @ Harry Road	4/14/2004	7:45	2.56

All flows were estimated from field measurements, since permanent gauges are not present.

The major water quality results for the wet season are outlined below:

- **Suspended solids.** The ranges for the tributaries and creeks are summarized below:
  - Tributaries to Alamitos Creek: 1.1 mg/L (Greystone Creek and upstream site on Randol Creek) to 16.9 mg/L (Calero Creek)
  - Alamitos Creek: 2.2 mg/L to 9.1 mg/L
  - Almaden Lake Outlet: 11.2 mg/L to 12.3 mg/L
  - Tributaries to Guadalupe Creek: 0.9 mg/L (Pheasant Creek) to 1.8 mg/L (Shannon Creek)
  - Guadalupe Creek: 2.0 mg/L to 13.4 mg/L

- **Mercury.** The total mercury concentrations in the samples are summarized below:
  - Tributaries to Alamitos Creek: 3.6 ng/L (upstream site on Randol Creek) to 37.1 ng/L (Golf Creek)
  - Alamitos Creek: 34.3 ng/L to 139.5 ng/L
  - Almaden Lake Outlet: 36.5 ng/L to 49.5 ng/L
  - Tributaries to Guadalupe Creek: 2.0 ng/L (Pheasant Creek) to 2.7 ng/L (Shannon Creek)
  - Guadalupe Creek: 13.8 ng/L to 40.3 ng/L

- **Methylmercury.** The total mercury concentrations in the samples are summarized below:
  - Tributaries to Alamitos Creek: 0.06 ng/L (Deep Gulch) to 0.43 ng/L (Golf Creek)
  - Alamitos Creek: 0.26 ng/L to 0.55 ng/L
  - Almaden Lake Outlet: 0.28 ng/L to 0.32 ng/L
  - Tributaries to Guadalupe Creek: 0.02 ng/L (Cherry Springs Creek) to 0.06 ng/L (Pheasant Creek)
  - Guadalupe Creek 0.24 ng/L to 0.57 ng/L.

Total and dissolved mercury concentrations are shown in Figure 3-6 for both Alamitos and Guadalupe creeks. Alamitos Creek was highest on April 20th at the bridge below Hacienda Yard (139.5 ng/L at E2-9), remained high at the Harry Road location (97.3 ng/L at E2-10), but decreased to 39.2 ng/L before entering Almaden Lake. The tributaries entering Alamitos Creek below Harry Road (Golf, Greystone, and Randol) had lower mercury concentrations than the main stem, and lower flows. The highest total mercury concentration in Guadalupe Creek was measured below Masson Dam on April 20th (40.3 ng/L at E2-6), when the upstream sample at the Old Gauge (E2-5) was less (28.1 ng/L). Mercury was almost as high in the main stem of Guadalupe Creek above Cherry Springs Creek (33 ng/L), even though the tributaries

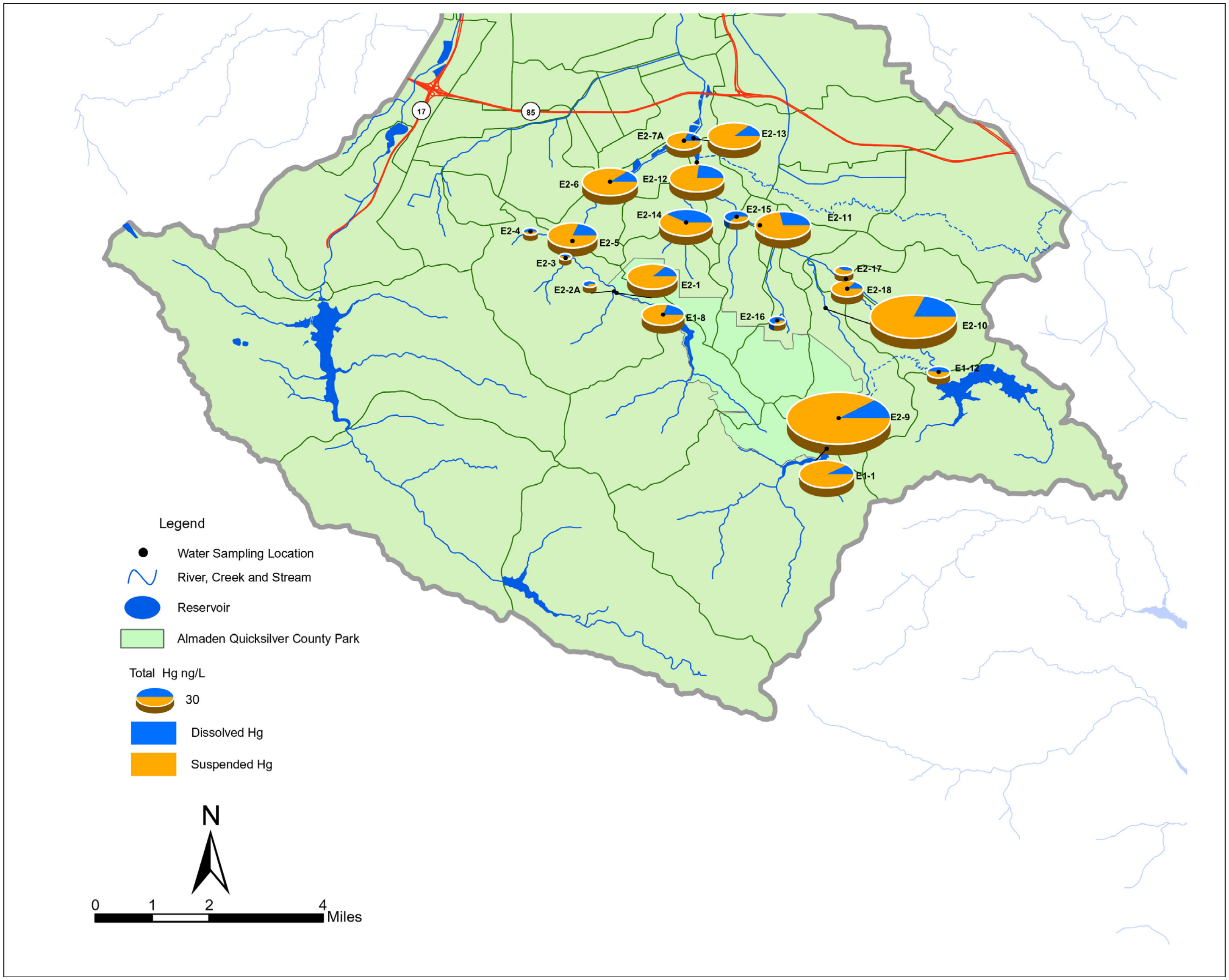


Figure 3-6. Total and dissolved mercury concentrations in Alamitos and Guadalupe Creeks and tributaries.

between this location and the dam were low (2.0 ng/L in Pheasant Creek and 2.7 ng/L in Shannon Creek). These results suggest that mercury is coming from resuspended sediments. Guadalupe Creek above its confluence with Alamitos Creek had variable mercury concentrations (13.8 ng/L on the non-storm day when the flow was about 7 cfs and 16.1 to 32.7 ng/L for the April sampling events when the flow was 1-2 cfs). The decreased suspended solids and total mercury at the confluence are consistent with deposition behind Masson Dam.

Particulate mercury concentrations were greater than 0.2 mg/kg in all the samples collected from Alamitos and Guadalupe Creeks and their tributaries. The total mercury in particulates of Alamitos Creek were greater than 10.0 mg/kg, between the bridge below Hacienda Yard and its confluence with Almaden Lake. The tributaries to Alamitos Creek have lower particulate mercury (0.68 mg/kg in Calero Creek to 7.8 mg/kg in Golf Creek) than the main stem (10.3 mg/kg to 23.8 mg/kg). The lake outlet samples had lower mercury content (2.6 to 4.0 mg/kg) than the upstream main stem, showing that some deposition of the high mercury suspended solids is occurring in the lake. The tributaries to Guadalupe Creek had lower particulate mercury (0.8 mg/kg in Shannon Creek to 1.2 mg/kg in Pheasant Creek) than the main stem (1.1 mg/kg to 14.8 mg/kg).

Methylmercury in the tributaries to Alamitos Creek below Harry Road (0.12 ng/L in Randol Creek to 0.43 ng/L in Golf Creek) were higher than the tributaries to Guadalupe Creek (0.02 to 0.06 ng/L). Methylmercury concentrations on Alamitos Creek were similar below the bridge near the AQC Park (0.51 ng/g) to Harry Road (0.55 ng/L), and then decreased downstream to the inlet to Almaden Lake (0.28 to 0.31 ng/L), as seen in Figure 3-7. The Almaden Reservoir outlet, when sampled on April 14, had a lower methylmercury concentration (0.29 ng/L). A methylmercury maximum was observed in Guadalupe Creek below Masson Dam (0.57 ng/L on April 20th). The methylmercury at the Guadalupe Reservoir outlet on April 14 was higher (0.7 ng/L) than the above downstream location. The methylmercury concentration was lower in the upstream reach of Guadalupe Creek at the Old Gauge (0.35 ng/L) than at Masson Dam on April 20th. This trend indicates that some in-situ methylation or resuspension of methylmercury-bearing sediment is occurring above Masson Dam. Methylmercury concentrations decrease from below the dam to the mouth of the creek at Almaden Expressway.

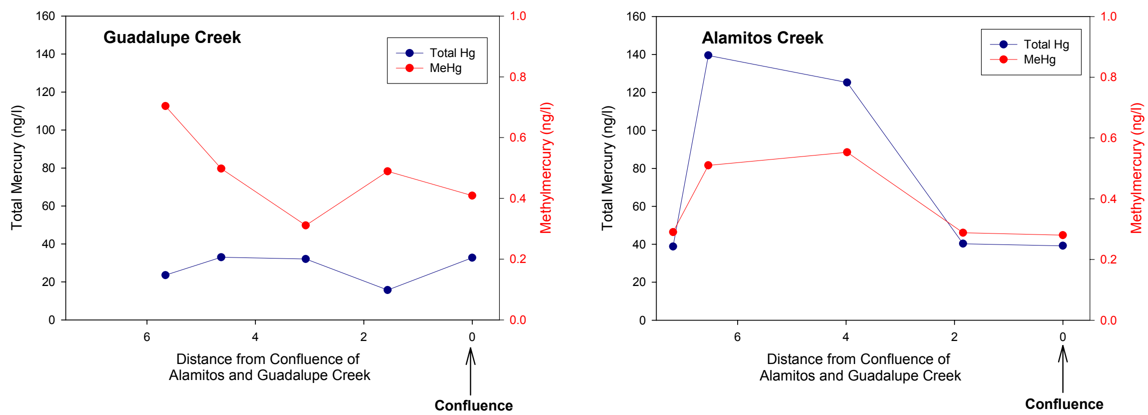


Figure 3-7. Mercury species along Guadalupe and Alamitos Creeks in April 2004

Mercury and other parameters were measured at some of the same locations sampled in the Synoptic Survey and the wet season. Results for locations sampled for Alamitos and Guadalupe Creeks are presented in Table 3-3. Total mercury at the reservoir outlets was higher in the wet season than the dry season samples from July 2003, while methylmercury exhibited the opposite trend. Total mercury concentrations increased in the wet season samples at the mouth of Alamitos Creek. Methylmercury was higher in the summer for both Alamitos and Guadalupe Creeks, due to reservoir releases. The higher total mercury concentration in Alamitos Creek at Harry Road in July 2003 is due to higher suspended solids (14 mg/L), compared to the April sample (4.6 mg/L). The decrease in methylmercury with distance from the reservoirs in the July 2003 samples was due to demethylation, uptake, and some sediment deposition.

Increased sediments during storm events can be introduced from sediment pick-up by overland runoff, urban runoff and pick-up of sediment present in stormdrains, bank erosion and resuspension of bedded sediment in a creek channel or tributaries. The main stem receives the sediment contributions from its tributaries , direct urban runoff, and stormdrains, in addition to bank erosion and resuspension of sediment in the channel of the main stem. A survey of creek reaches where erosion was occurring or likely such as along undercut banks was conducted in 2003; these locations are shown in Figure 3- 8. Example photographs of the sites are shown in Figure 3-9. At several locations along Alamitos Creek, erosion may cause mine wastes to be discharged into the creek. At other locations such as along Ross Creek, sediment from an urban area would be discharged to the creek, which also contributes to the total mercury load in the Guadalupe River.

Table 3-3.
Comparison of Dry and Wet Season Results for Alamitos and Guadalupe Creeks

Location	2004 Sample ID	Total Mercury, ng/L			
		February-00	July-03	March-04	April-04
Almaden Reservoir Outlet	E1-1	NS	7.49	36.6	38.79
Deep Gulch Creek	E2-8	NS	108.6	13.41	NS
Alamitos Creek at Harry Road	E2-10	NS	435.9		125.2
Alamitos Creek above Almaden Lake	E2-12	NS	25.88	86.49	39.32
Guadalupe Reservoir Outlet	E1-8	NS	18.89	77.4	23.56
Guadalupe Creek at Old Gauge	E2-5	82.8	33.15	NS	28.07
Guadalupe Creek above Almaden Expressway	E2-7	74.1	38.9	13.82	32.75

Location	2004 Sample ID	Methylmercury, ng/L			
		February-00	July-03	March-04	April-04
Almaden Reservoir Outlet	E1-1	NS	4.34	0.328	0.29
Deep Gulch Creek	E2-8	NS	0.2	0.057	NS
Alamitos Creek at Harry Road	E2-10	NS	0.96	NS	0.553
Alamitos Creek above Almaden Lake	E2-12	NS	0.306	0.275	0.31
Guadalupe Reservoir Outlet	E1-8	NS	8.27	0.319	0.704
Guadalupe Creek at Old Gauge	E2-5	0.25	5.21	NS	0.355
Guadalupe Creek above Almaden Expressway	E2-7	0.51	0.99	0.242	0.409

The data obtained for Alamitos and Guadalupe Creeks show that in general total mercury increases as flow increases. High flows above 1,000 cfs can occur on both creeks for short durations based on an evaluation of historical flow data and 2003 and 2004 data, which would have greater suspended solids, and hence would contribute larger total mercury loads to the downstream Guadalupe River. For Guadalupe Creek, bank erosion and resuspension of sediment are important, since the tributaries have low mercury for all three forms. For Alamitos Creek, the tributaries also contribute less mercury than the upstream reaches of the creek, particularly from the bridge near AQC Park to Harry Road. Golf Creek, which includes McAbee Creek draining the former Senador mine area has the highest mercury concentrations (of all three forms) of any of the tributaries to Alamitos or Guadalupe Creeks. However, flow from Golf Creek only reaches Alamitos Creek under high flow conditions due to a series of upstream drop structures, which also retain sediment.

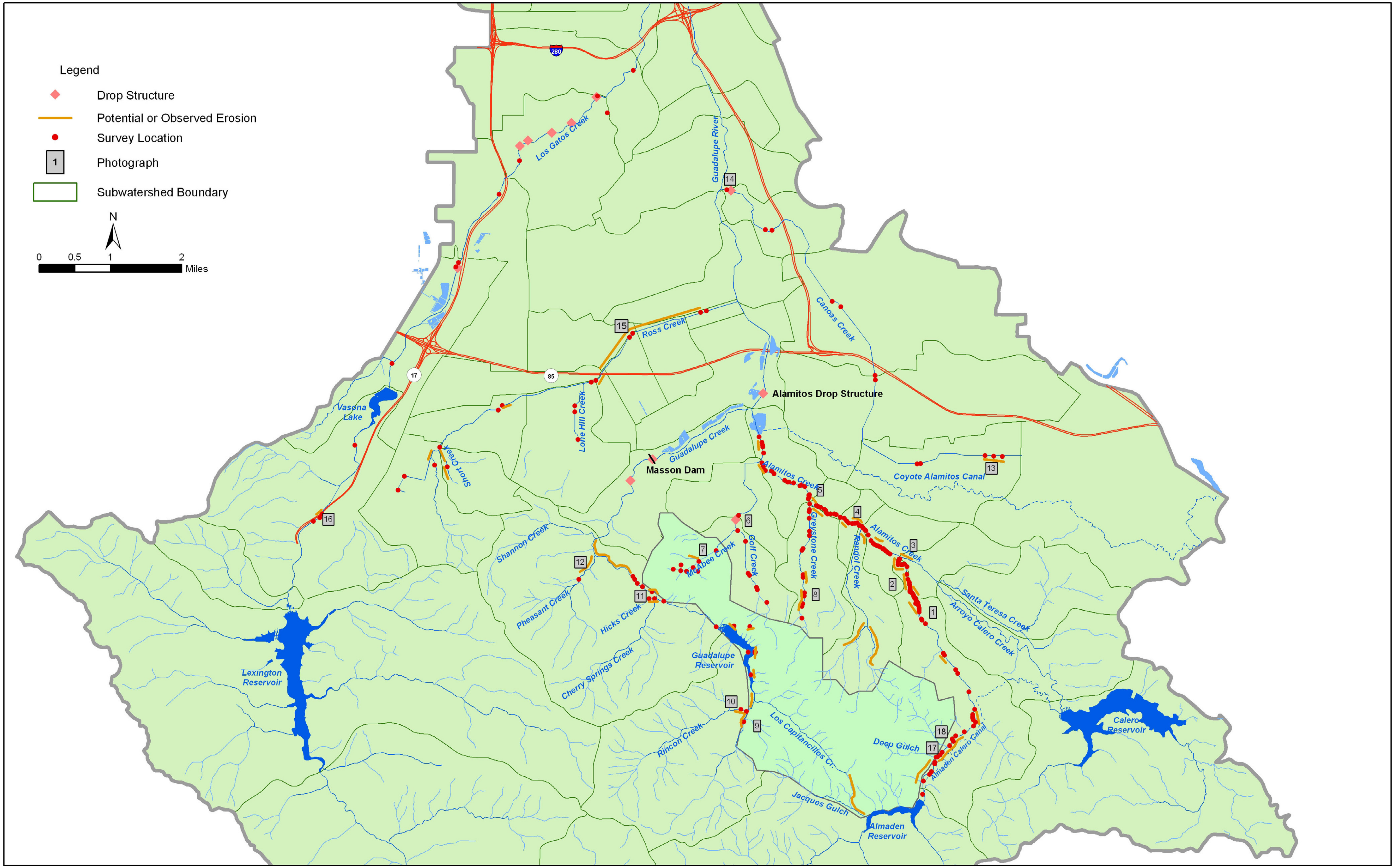


Figure 3-8. Location of potential erosion sites along the tributaries to the Guadalupe River.

Photographs of Potential Sediment Erosion Sites


Photo 1 **Eroding bank along Alamitos Creek**


Photo 2 **Undercut bank on Alamitos Creek**


Photo 3 **Gravel bar and undercut bank on Santa Teresa Creek**


Photo 4 **Potential erosion on Alamitos Creek**


Photo 5 **Steep bank on Alamitos Creek**


Photo 6 **Drop structure on McAbee Creek**


Photo 7 **Eroded bank on McAbee Creek below Senador Mine**


Photo 8 **Underbank on Greystone Creek**


Photo 9 **Potential bank erosion on Rincon Creek**


Photo 10 **Potential bank erosion on Rincon Creek**


Photo 11 **Potential bank erosion on Hicks Creek**


Photo 12 **Potential erosion on Pheasant Creek**


Photo 13 **Eroding bank on Canoas Creek**


Photo 14 **Drop structure on Canoas Creek**


Photo 15 **Eroded bank on Ross Creek**


Photo 16 **Potential erosion on Los Gatos Creek**


Photo 17 **Eroded bank on Alamitos Creek**


Photo 18 **Steep bank on Alamitos Creek**

Figure 3-9. Examples of sediment erosion and bank undercutting sites.

3.1.3 URBAN CREEKS

Limited data for mercury were previously available for the urban watersheds contributing to the Guadalupe River. The three urban creeks (Ross, Canoas, and Los Gatos) were sampled between February 27 and April 23, 2004. The locations (Figure 3-10) were selected to estimate the mercury load coming from urban areas and to determine if there are differences along the creeks. Measurements were made of suspended sediments, flow rates at ungauged locations, total and dissolved mercury, and methylmercury at each location. Dissolved methylmercury was measured at four of the locations (E3-1, E3-4, E3-5, and E3-7).

Water samples were collected at seven locations along Ross Creek, Canoas Creek, and Los Gatos Creek. The flows at the time of sampling are provided in Table 3-4. The chemical data are presented in the Data Collection Report (Tetra Tech, 2005a). The mercury results are summarized below:

- **Suspended Solids.** The suspended solids concentrations in the urban creeks and Guadalupe River are summarized below:
  - Ross Creek: 1.1 mg/L to 24.5 mg/L
  - Canoas Creek: 2.7 mg/L to 45.6 mg/L
  - Los Gatos Creek: 2.5 mg/L to 90.4 mg/L
  - Guadalupe River main stem: 5.0 mg/L to 118.6 mg/L.

- **Mercury.** Total mercury in the urban creeks and Guadalupe River are summarized below:
  - Ross Creek: 5.30 ng/L to 18.47 ng/L
  - Canoas Creek: 4.14 ng/L to 27.97 ng/L
  - Los Gatos Creek: 2.04 ng/L to 29.83 ng/L

  Guadalupe River main stem: 14.48 ng/L to 464.6 ng/L

Los Gatos Creek contributed higher suspended solids to the river than Ross or Canoas Creek, particularly when Vasona Reservoir spilled, as it did on February 27th. Los Gatos Creek contributed less total mercury and methylmercury than the tributaries influenced by mining, Alamitos and Guadalupe Creeks (Figure 3-11). Los Gatos and Canoas Creeks had similar maximum total mercury concentrations during the large flow event in February 2004, with the highest measured concentration below the Vasona Reservoir in Los Gatos Creek (29.8 ng/L) when the suspended solids was 90.4 ng/L. Los Gatos Creek had higher methylmercury below Vasona Reservoir and upstream of this reservoir than in the downstream locations on the same sampling day.

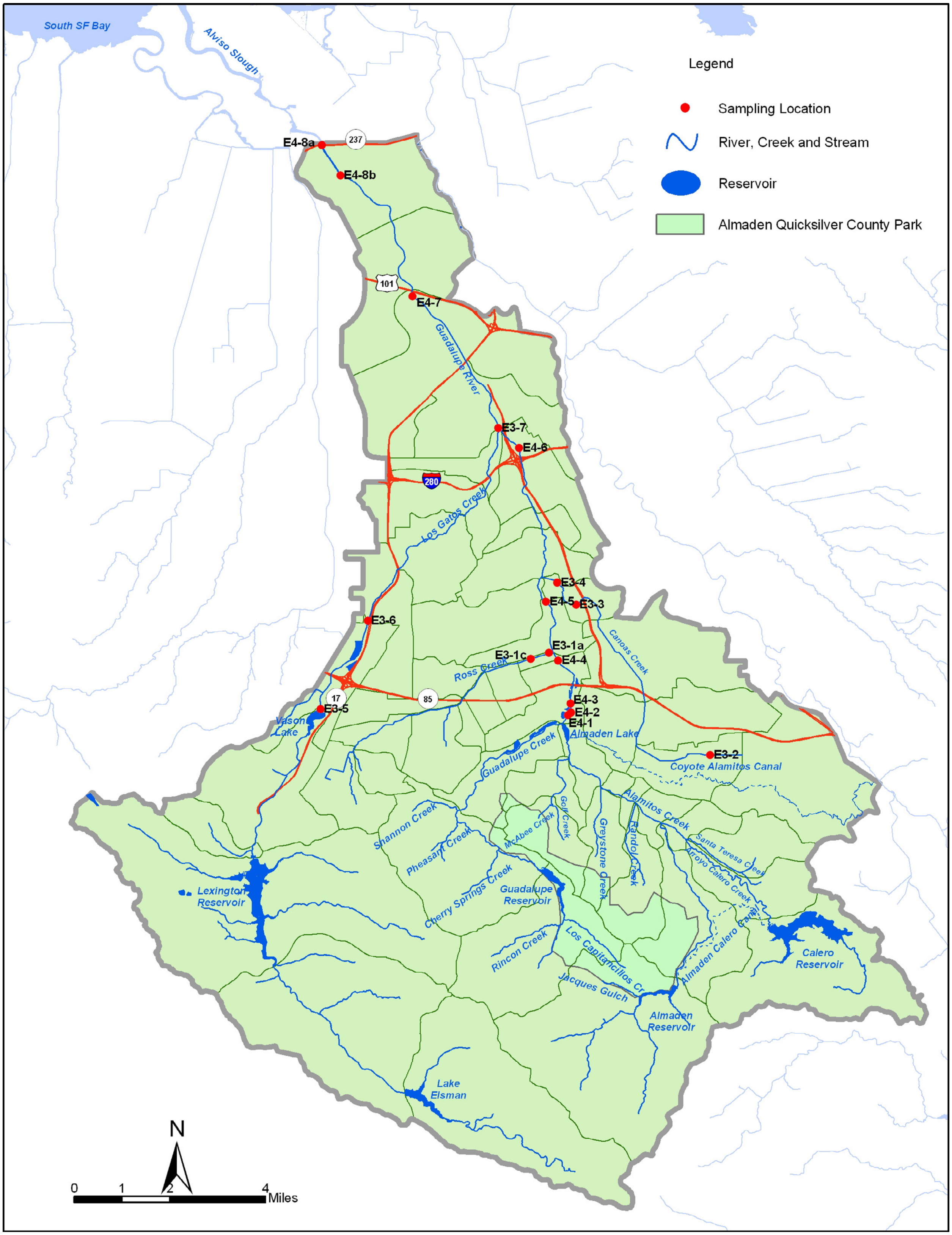


Figure 3-10. Sampling Locations for Urban Creeks and the Guadalupe River.

Table 3-4.
Flow Measurements at Elements 3 and 4 Sampling Locations, Wet Season 2004

Station No.	Station Name	Date	Time	Gauged Flows, cfs	Est. Flows, cfs
E3-1A	Ross Creek upstream of Guadalupe River	2/27/2004	14:00	12.5	
E3-1B	Ross Creek upstream of Guadalupe River (replicate)	2/27/2004	14:00	rep	
E3-1	Ross Creek upstream of Guadalupe River	3/8/2004	10:45	1.2	
E3-1	Ross Creek upstream of River (below Cherry Ave.)	4/23/2004	11:30	0.30	
E3-2	Canoas Creek at Lean Avenue	2/27/2004	14:45		1.5
E3-2	Canoas Creek at Lean Ave	4/20/2004	11:40		0.06
E3-3	Canoas Creek at Dow Drive	2/27/2004	13:00		4.12
E3-4	Canoas Creek upstream of Guadalupe River	2/27/2004	12:05	7.4	
E3-4	Canoas Creek upstream of Guadalupe River	3/8/2004	9:19	0.7	
E3-4	Canoas Creek upstream of Guadalupe River	4/20/2004	9:25	1	
E3-5	Los Gatos Creek below Vasona Reservoir Outlet	2/27/2004	8:35	spilling	79.2
E3-5	Los Gatos Creek below Vasona Reservoir Outlet	4/20/2004	8:10		18.72
E3-6	Los Gatos Creek at Camden Avenue	2/27/2004	9:30		9.92
E3-7	Los Gatos Creek above Guadalupe River	2/27/2004	10:20	18.1	
E3-7	Los Gatos Creek above Guadalupe River	3/8/2004	8:45	2.7	
E3-7	Los Gatos Creek upstream of Guadalupe River	4/20/2004	8:50	31.8	
E4-1	Guadalupe River above Alamitos Drop Structure	2/26/2004	8:50		NA
E4-1	Guadalupe River above Alamitos Drop Structure	4/20/2004	8:40		NA
E4-2	Guadalupe River below Alamitos Drop Structure	2/26/2004	9:25		spilling
E4-2	Guadalupe River below Alamitos Drop Structure	3/8/2004	11:30	20.87	NA
E4-2	Guadalupe River below Alamitos Drop Structure	4/20/2004	9:08	9.51	NA
E4-3	Guadalupe River at Blossom Hill Road	2/27/2004	9:15	57	
E4-3	Guadalupe River at Blossom Hill Road	4/20/2014	8:20	9.6	
E4-4	Guadalupe River upstream of Ross Creek Inflow	2/27/2004	10:10		NA
E4-4	Guadalupe River upstream of Ross Creek Inflow	3/8/2004	11:10		30.96
E4-4	Guadalupe River upstream of Ross Creek Inflow	4/20/2004	10:40		9.18
E4-5	Guadalupe River upstream of Canoas Creek Inflow	2/27/2004	10:30	174.6	
E4-5	Guadalupe River upstream of Canoas Creek Inflow	3/8/2004	9:42	31.5	NA
E4-5	Guadalupe River upstream of Canoas Creek Inflow	4/20/2004	9:55	9.9	
E4-6	Guadalupe River at San Carlos Street	2/27/2004	11:10		NA
E4-6	Guadalupe River at San Carlos Street	4/20/2004	11:55		NA
E4-7	Guadalupe River at Highway 101	2/26/2004	10:25	807	
E4-7	Guadalupe River at Hwy 101	4/20/2004	12:25	29.00	
E4-7A	Guadalupe River at Highway 101	3/8/2004	15:10	45	
E4-7B	Guadalupe River at Highway 101 (replicate)	3/8/2004	15:10		rep
E4-8	Guadalupe River at HWY 237	2/27/2004	12:00		NA
E4-8	Guadalupe River at Hwy 237	4/20/2004	13:00		NA

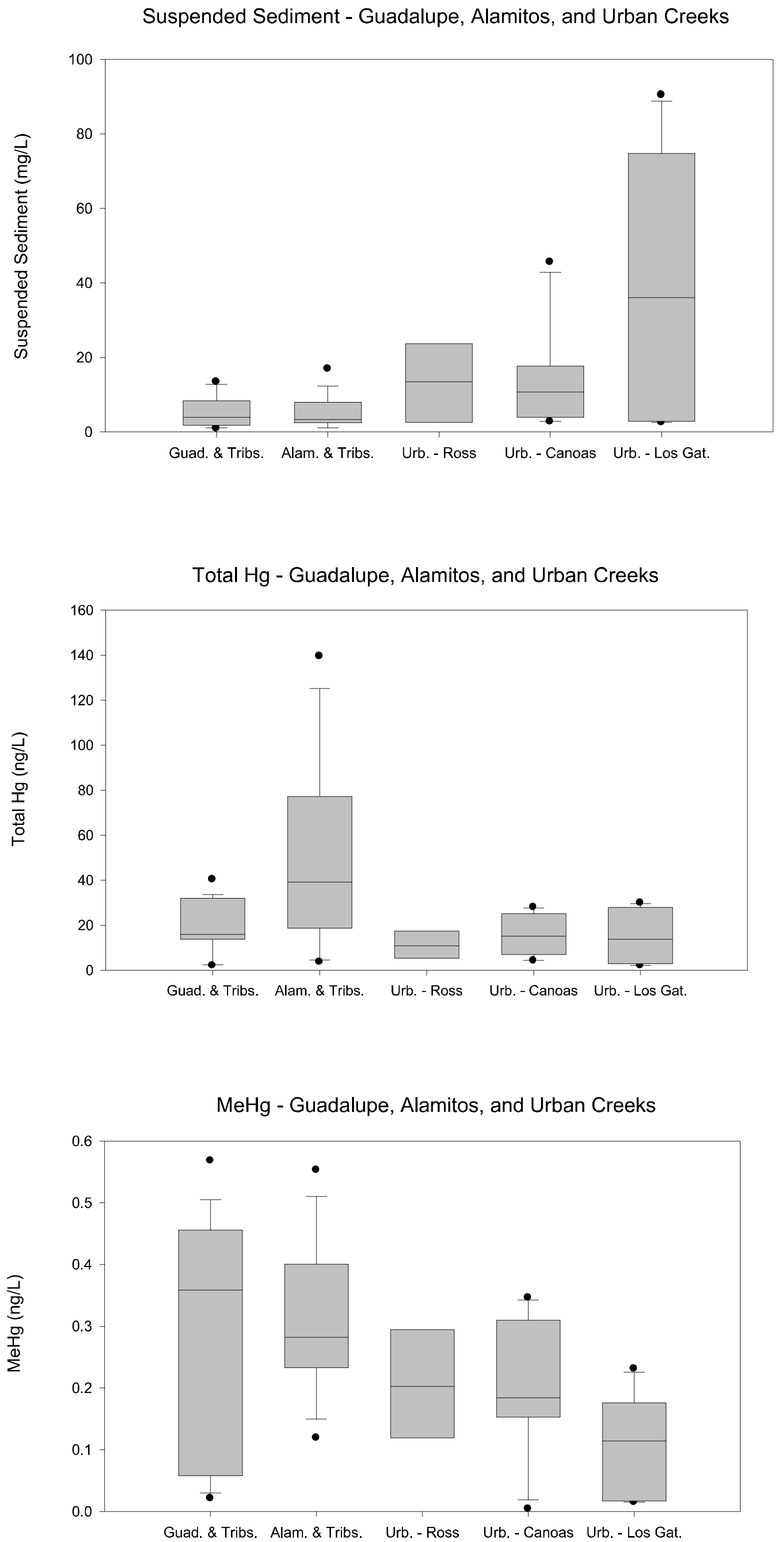


Figure 3-11. Box Plots Comparing Suspended Sediment, Total and Methylmercury for Urban Creeks and Upstream Tributaries to Guadalupe River.

3.1.4 GUADALUPE RIVER

The main stem of the Guadalupe River was sampled on three dates between February 26 and April 20, 2004 at eight locations on the Guadalupe River to characterize the wet season runoff. The sampling locations are shown on the map with the urban creeks (see Figure 3-10). The flows at the time of sampling were included in Table 3-4. Measurements were made of suspended sediments, total and dissolved mercury, and methylmercury at each location. Dissolved mercury and dissolved methylmercury were measured at two of the locations (E4-7 and E4-8).

Mercury along the Guadalupe River and urban creeks are compared for a moderate and small storm in Figure 3-12. In all three events, total mercury was higher in the upper part of the river near the Alamitos Drop Structure, compared to the lower part by Highways 101 and 237. The 2004 wet season sampling of the Guadalupe River at the Highway 101 gauge showed the highest total mercury (363.9 ng/L) on the day with the highest flow (807 cfs) and the lowest total mercury (14.5 ng/L) on the day with the lowest flow (29 cfs). The total mercury at Highway 237 ranged from 32.8 ng/L to 182.5 ng/L. The range of total mercury in the urban creeks before the confluence with the river was considerably less: 2.0 to 21.8 ng/L in Los Gatos Creek, 5.3 to 18.5 ng/L in Ross Creek, and 4.1 ng/L to 12.3 ng/L in Canoas Creek. The contribution from the mining-influenced creeks, Alamitos and Guadalupe Creeks, was higher (65.8 ng/L to 464.6 ng/L) as measured below the Alamitos Drop structure.

The suspended solids were higher in the large storm event (46.1 to 118.6 mg/L) than the small storm (7.1 to 17.7 mg/L). With the exception of the sampling location at Blossom Hill Road, all forms of mercury along the river were highest in the large storm event, including methylmercury. A possible explanation for the increase in total mercury concentration at Blossom Hill Road in the April 20th sample is that sediment can spill over the Alamitos Drop Structure during high flow events. The mercury-bearing sediment can then be resuspended and transported downstream by succeeding storms.

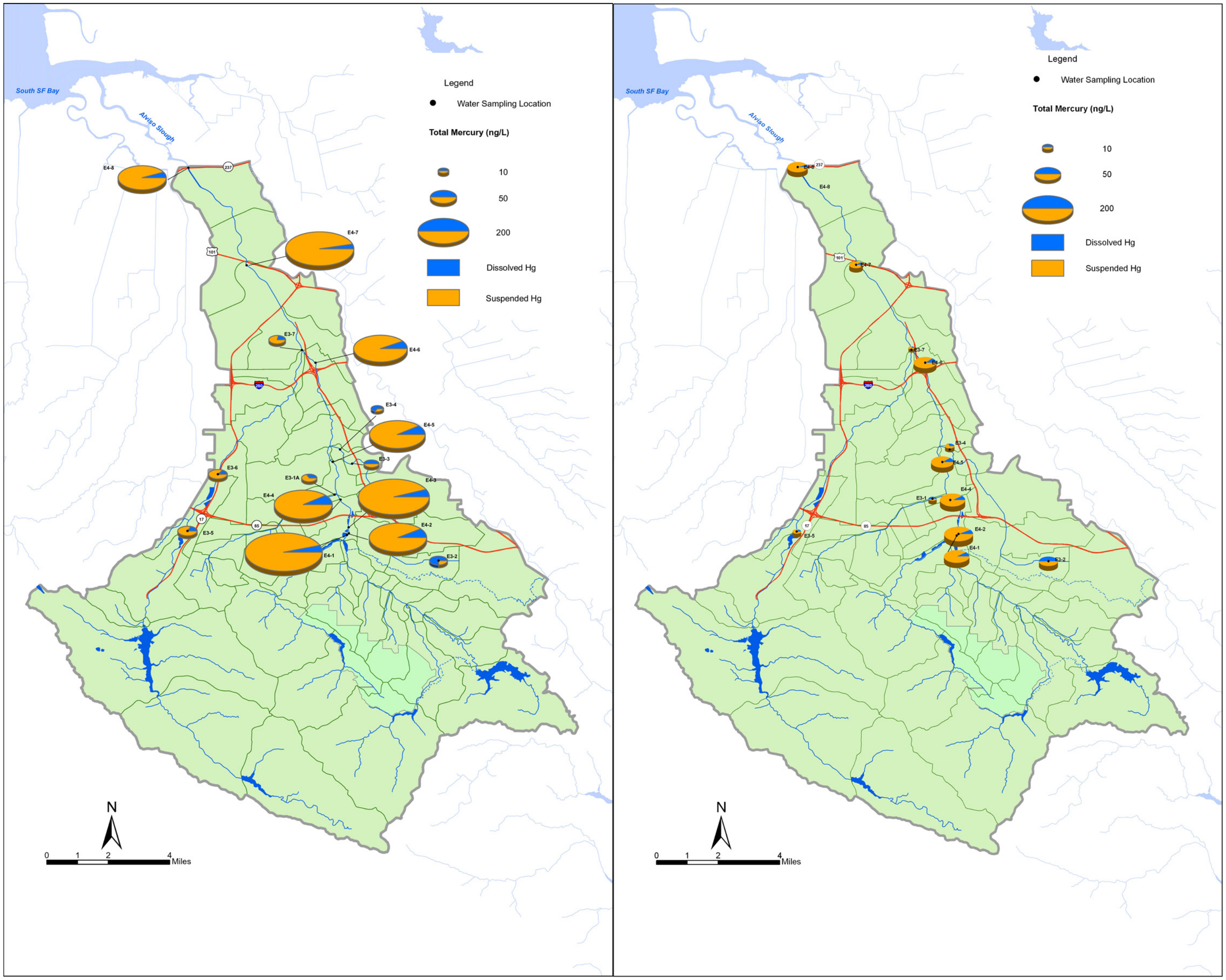


Figure 3-12. a)Total and Dissolved Mercury for Moderate Flow Event February 26-27, 2004 and b)Total and Dissolved Mercury for Small Storms – April 2004.

The methylmercury in the three urban creeks ranged from 0.004 to 0.23 ng/L, compared to the river locations that ranged from 0.16 to 0.9 ng/L. The highest methylmercury in the river samples on the highest flow day (2/26/04) was above and below the Alamitos drop structure (0.92 ng/L); the concentrations decreased below the drop structure (0.74 ng/L) and remained at a similar concentration at Highway 101 (0.75 ng/L). The following day, there was an increase in methylmercury concentrations from the Blossom Hill site (0.56 ng/L) to the reach above Ross Creek (0.65 ng/L) and San Carlos Street (0.59 ng/L), which may be due to resuspension of sediment from the river bottom. On the low flow events, methylmercury concentrations decreased at both Highway 101 and 237, compared to the concentrations upstream at San Carlos Street. Most of the methylmercury was associated with the particulate phase, rather than the dissolved phase.

Particulate mercury concentrations are compared in Figure 3-13. The three urban creeks had low concentrations compared to the main stem of the Guadalupe River. The urban creeks are similar to the upper watershed creeks not affected by mining, representing background conditions. The highest particulate mercury concentrations were observed in the creeks affected by mining, particularly Alamitos Creek. (Figure 3-14). The river samples have less variability, but are in the range of Guadalupe and Alamitos Creeks. The particulate mercury concentrations were similar along the main stem of the Guadalupe River from the confluence of Alamitos and Guadalupe Creeks to above Canoas Creek, then decreased toward the Bay. All particulate data are presented in the Data Collection Report (Tetra Tech, 2005a).

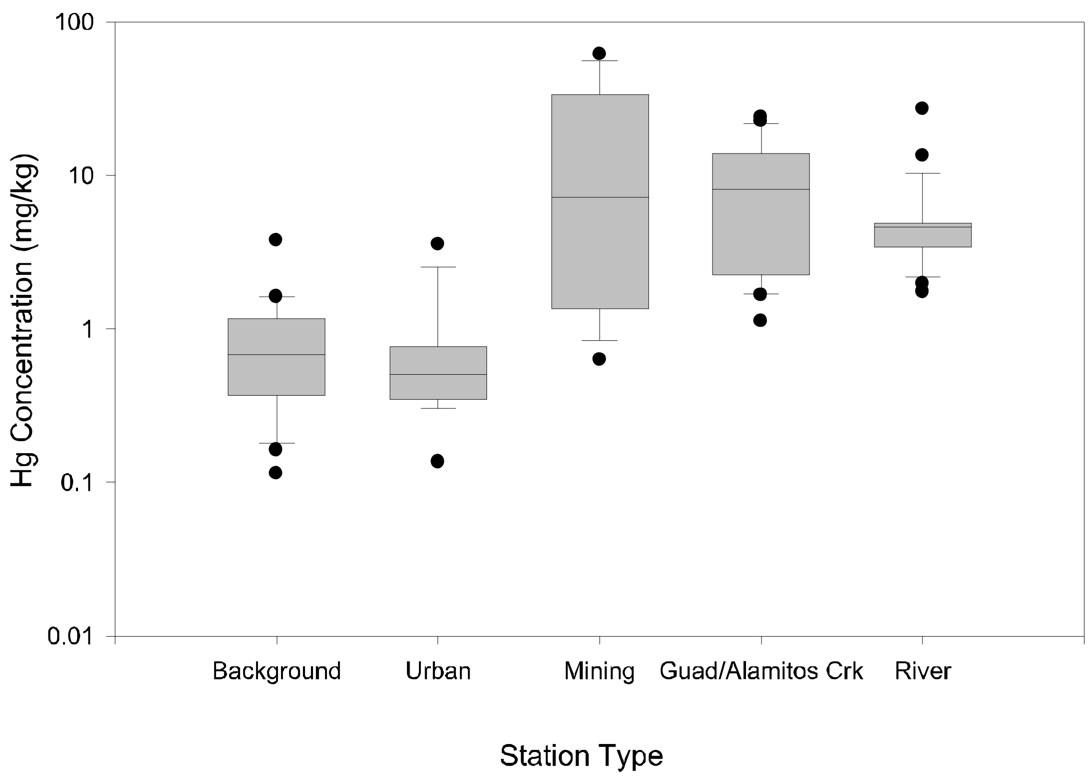


Figure 3-13. Particulate Mercury Concentrations by Waterbody Group.

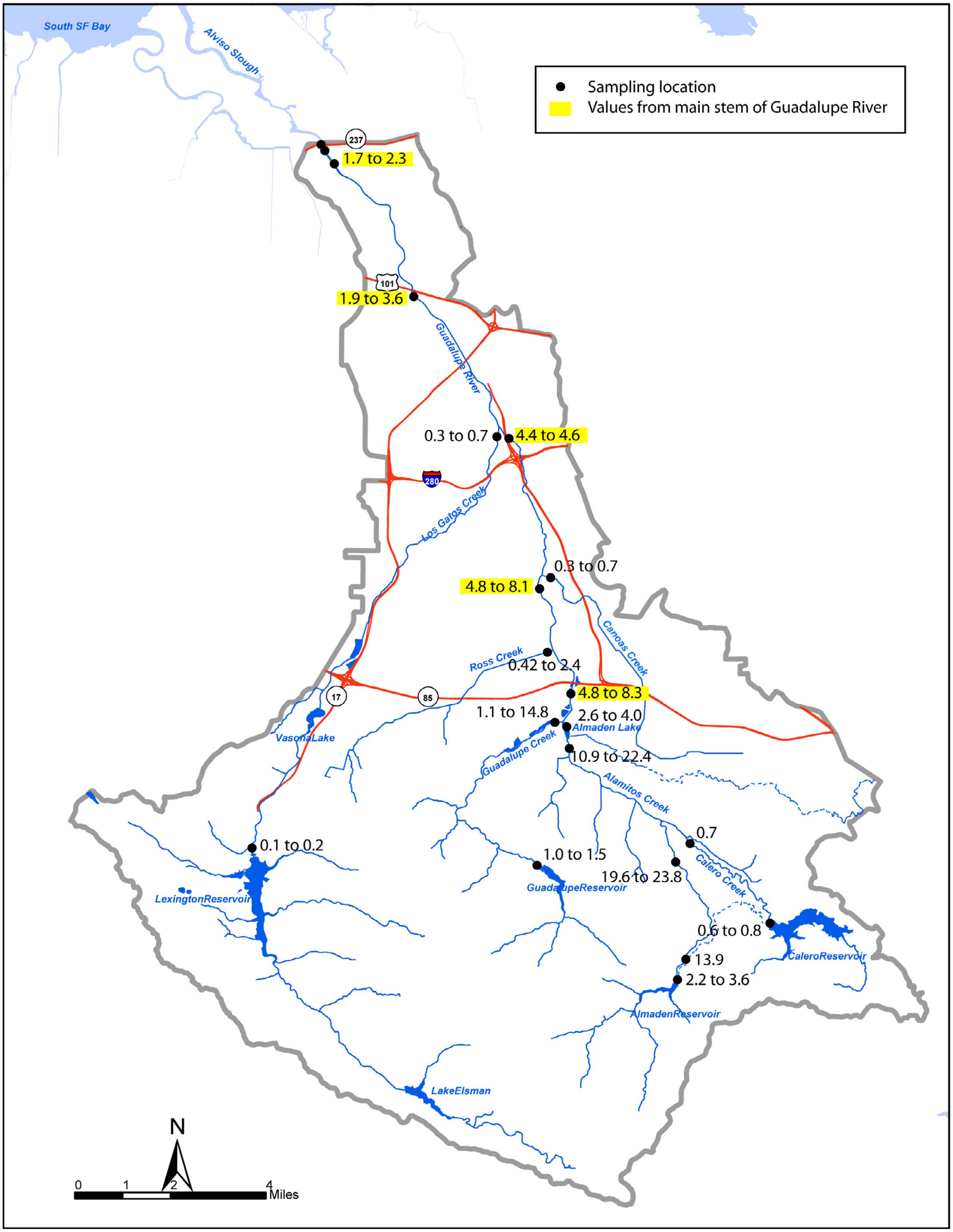


Figure 3-14. Particulate Mercury (mg/kg) at key locations in Guadalupe River Watershed from 2004

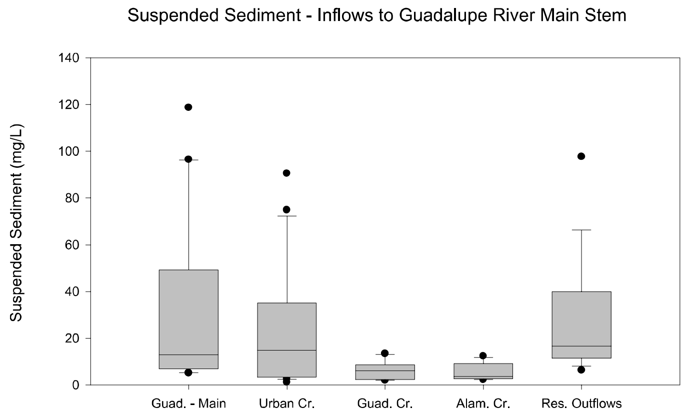
The measured concentrations of total and methylmercury and suspended solids are compared for the urban creeks, creeks affected by mining, and the reservoir outlets in Figure 3-15. The maximum total mercury and methylmercury concentrations were highest in the Guadalupe main stem. These plots show that the urban creeks contribute more suspended solids, but less total and methyl mercury than the two creeks affected by mining. The reservoir outlets had higher methylmercury concentrations in some, but not all the outlets, compared to the urban creeks. The maximum methylmercury concentration (0.92 ng/L) was measured in the sample above the Alamitos Drop Structure; the second highest concentration (0.75 ng/L) was from Highway 101 for the high flow event (both on the high flow sampling day - February 26, 2004 when the flow at the new USGS gauge near Highway 101 was 807 cfs – see Table 3-4).

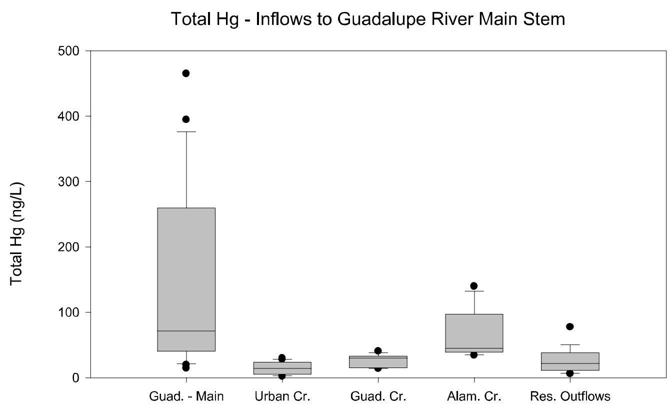
Large storms result in much higher flows below the confluence with Los Gatos Creek than sampled for the TMDL project. In the 2002–2003 water year, mercury samples for such large storms were analyzed for SFEI. The total mercury concentrations ranged from 0.18 µg/L to 18.67 µg/L between November 7, 2002 and May 29, 2003 for 27 samples (McKee et. al., 2004). The maximum mercury concentration was sampled on December 16, 2002 when the flow at the old USGS gauge on St John's Street was about 4,500 cfs and the suspended solids was 967 mg/L. The total mercury concentration at the gauge was 4.96 µg/L on May 29, 2003 when the flow was less than 100 cfs and suspended solids was18.1 mg/L. These results are much higher than the results from the 2004 results, the USGS study discussed above by Thomas, and recent sampling by the Army Corps of Engineers (ACOE, 2004). The higher mercury concentrations for extreme flood conditions are expected, but the measured mercury concentrations were also higher for low flow conditions.

3.2 WET SEASON SEDIMENT SAMPLING

3.2.1 UPSTREAM TRIBUTARIES

Sampling was conducted to compare total mercury and methyl mercury in sediment from creeks in the mining area and from Alamitos and Guadalupe Creeks to bank soil and bottom sediment from the Guadalupe River. The sediment in the mining area creeks was collected to determine the potential for resuspension and transport of mercury-bearing sediment. Sampling was conducted once at each location. Mining area bottom sediment samples were collected from the Mine Hill tributary to Jacques Gulch (E1-7S) and N. Los Capitancillos Creek (E1-9S) (see Figure 3-16). These samples were analyzed for total and methylmercury, grain size distribution, and moisture. A sampling location on McAbee Creek, a tributary to Golf Creek, was added (E2-19S), since a large debris dam was found in the creek below the Senador Mine entrance to the Almaden Quicksilver County Park (AQCP). Both bottom and bank samples were collected and analyzed for total mercury. Sediment samples, primarily gravels, were also collected from two deposition areas: where Alamitos Creek enters Almaden Lake and at the confluence where Guadalupe Creek meets Alamitos Creek below the lake. These samples were analyzed for total and methylmercury, grain size distribution, and moisture.





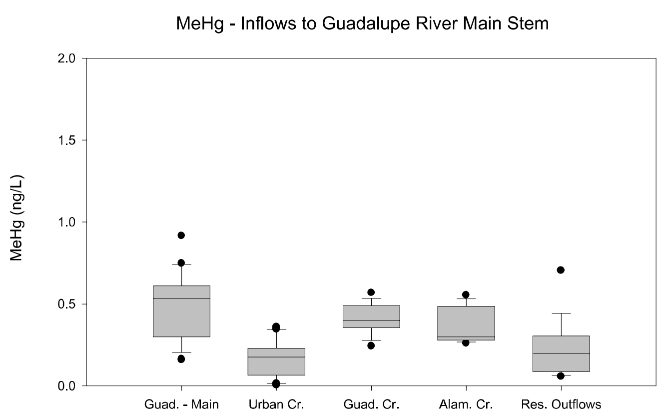


Figure 3-15. Box Plots Comparing Suspended Sediment, Total and Methyl Mercury for Guadalupe River Main Stem to Inputs.

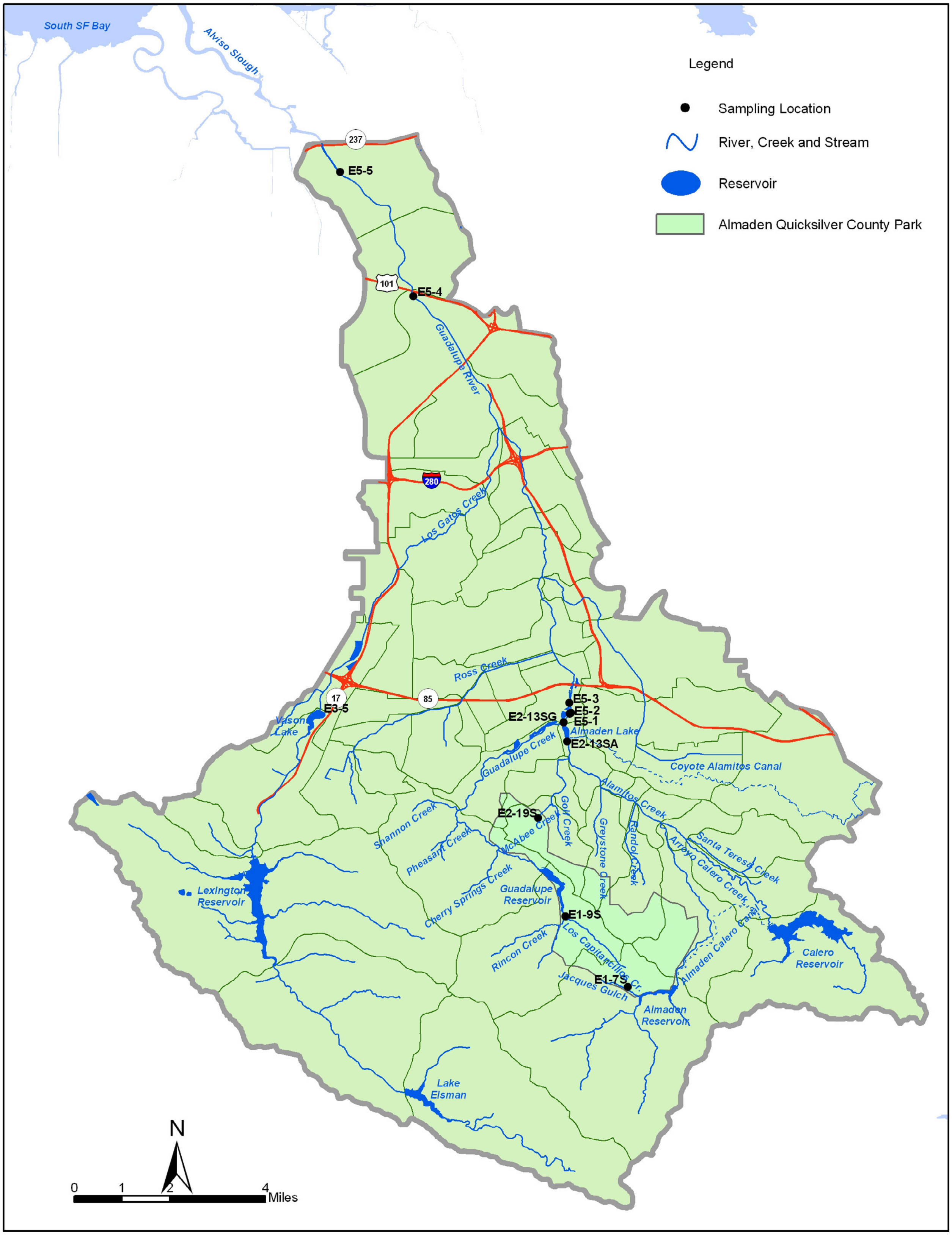


Figure 3-16. Sediment Sampling Locations for Wet Season 2004

3.2.2 GUADALUPE RIVER

Sediment transport is an important factor in the release of mercury to San Francisco Bay. Sediment samples were collected from the Guadalupe River at five locations as shown on the map (Figure 3-16) on March 8, 2004. At each of four locations along the Guadalupe River, four samples were collected: two bottom sediment samples and two bank samples. At one of these locations (E5-4), an additional set of four samples was collected to provide an estimate of variability. One additional sediment sample was collected from above the Alamitos Drop Structure on the Guadalupe River in the built-up sediment above the upstream wall. The sediment samples were analyzed for total mercury, methylmercury, moisture content, and grain size. In addition, samples were collected at three locations (E5-2, E5-4, and E5-5) from the river bottom for analysis of sulfate and sulfide.

Additional analyses were conducted to evaluate relationships between mercury and grain size and the potential leachability, and hence bioavailability, of the mercury. In general, the leachability was less in coarse sediment samples from the mining area creeks, than in the fine-grained sediment from the river bottom near the Bay. The predominant form of the mercury based on the sequential extraction tests (Bloom et al, 2003) was cinnabar, consistent with the source of the ores from silica carbonate deposits.

The sediment results are presented in the Data Collection Report (Tetra Tech, 2005a). The concentrations presented on maps, plots, and discussed in the text are presented on a dry weight basis. Notable findings from the sediment samples are:

- **Mercury**. The total mercury concentrations in the sediment samples (dry-wt basis) are summarized below:
  - mercury in sediment from creeks in the mining area ranged from 0.18 mg/kg to 18.65 mg/kg.
  - mercury in sediment in the deposition areas at the end of Alamitos and Guadalupe Creeks ranged from 16.45 mg/kg to 18.78 mg/kg.
  - mercury in sediment from the Guadalupe River ranged from 0.065 mg/kg to 39.28 mg/kg.

- **Methylmercury**. The methylmercury concentrations in the sediment samples are summarized below:
  - 0.05 ng/g to 0.14 ng/g in sediment from creeks in the mining area; 0.06 ng/g to 0.29 ng/g in sediment from the deposition areas at the end of Alamitos and Guadalupe Creeks;
  - 0.05 ng/g to 3.2 ng/g in sediment from the Guadalupe River.

The total mercury concentrations at key locations are shown in Figure 3-17 from both the wet season and the synoptic survey. The river samples from Highways 101 and 237 were less than the upper river samples. For most sediment samples, the total mercury concentrations were higher in the bank sediments than the bottom sediments. The urban creeks had low mercury concentrations, compared to the main stem and the

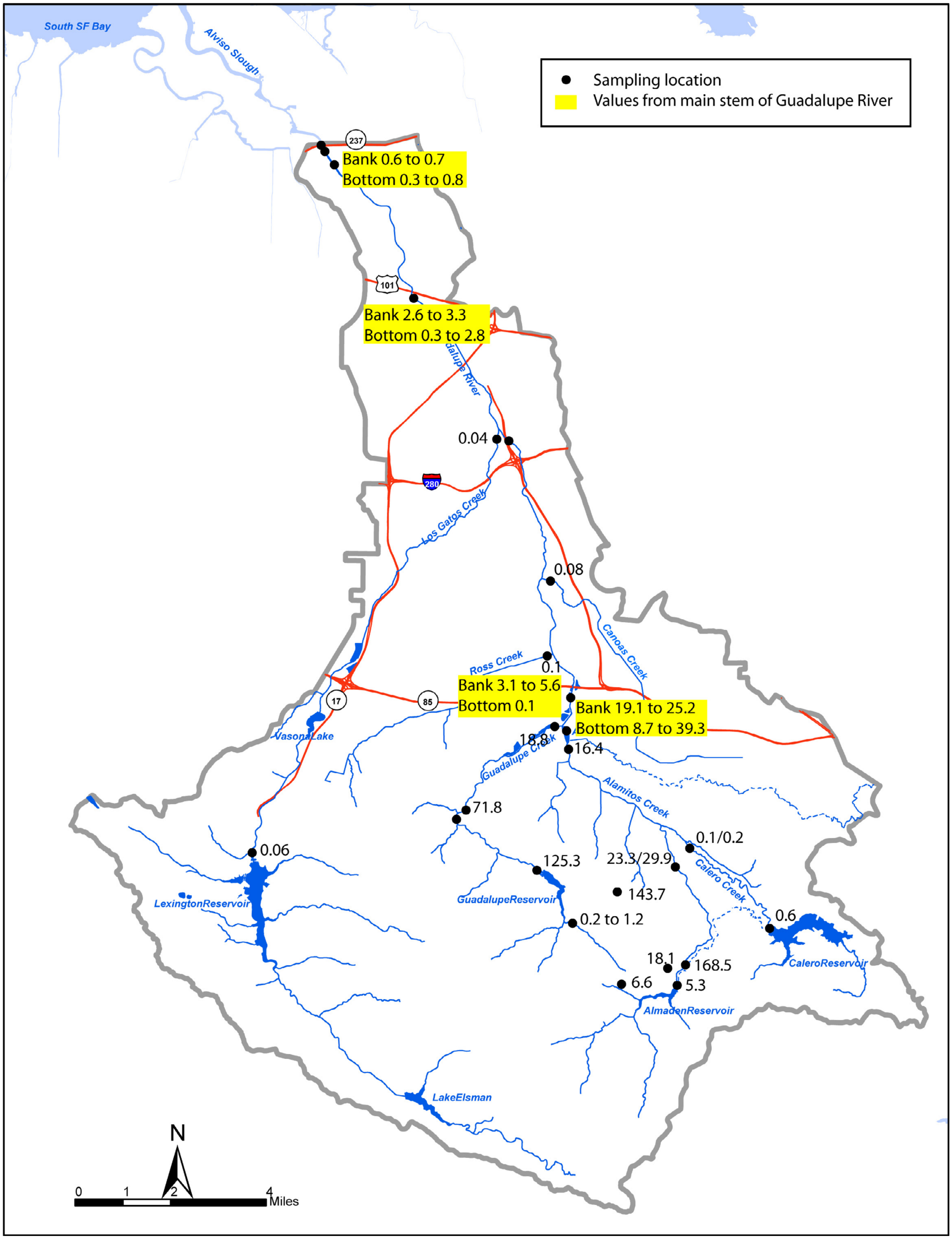


Figure 3-17. Total mercury concentrations (mg/kg) in Sediment Samples at Key Locations in the Guadalupe Watershed in 2004

tributaries affected by mining. The sediment mercury concentrations on Alamitos and Guadalupe Creeks are high due to past transport of mine wastes.

In the upper reaches of the river, the bottom samples had higher methylmercury concentrations than the bank samples. While the sediment data are variable, the general trend of the bottom samples was that total mercury was highest below the drop structure, then low at Blossom Hill Road, higher at Highway 101, then decreasing at Highway 237. The importance of the higher mercury in the bank samples is that during high flow events, erosion or sloughing of the bank soils can occur, which introduces higher mercury-bearing sediment to the river.

3.3 Dry Season Reservoirs

Methylmercury is the chemical form of mercury most directly linked to uptake by biota. An understanding of methylation processes in reservoirs is needed to develop the linkage between water column and fish mercury. Almaden and Guadalupe Reservoirs were sampled on six dates between May 11 and August 31, 2004. Measurements of total and dissolved mercury and methylmercury in water, and associated parameters (dissolved oxygen, sulfate, sulfide, dissolved organic carbon, and nutrients) were made in these two reservoirs to follow the development of stratification and its effect on net methylmercury production. The mercury samples were collected from the reservoirs from the epilimnion and below the thermocline at mid-depth of the hypolimnion, and at the outlets of the two reservoirs. Depth profiles for temperature, specific conductivity, pH, dissolved oxygen, and turbidity were developed using *in situ* measurements.

3.3.1 Sample Results: Reservoirs

The outflows from both reservoirs were low during the dry season, between 1.7 and 10.3 cfs from Guadalupe Reservoir and between 5.2 and 5.6 cfs from Almaden Reservoir with a few short-duration high flow events (lasting a few hours) of up to 167 cfs. There was only one small rain event on May 28th during the sampling period with 0.08 inches of rain at the rain gauges within both reservoir watersheds. There were no transfers from Almaden Reservoir to Calero Reservoir during this period with the possible exception of two brief, hour-long events in mid-July of 16 and 18 cfs, based on the automated gauge readings.

All dry-season data on mercury and related water chemistry in the reservoirs are presented in the Data Collection Report (Tetra Tech, 2005a). Key findings from data on mercury speciation are summarized below. The outlet samples represent a deeper depth in the reservoir than the mid-depth hypolimnion samples.

- **Suspended solids.** The suspended solids concentrations were higher in Guadalupe Reservoir, as shown below:
  - Almaden Reservoir: 0.8 mg/L to 4 mg/L
  - Almaden Reservoir outlet: 1.4 mg/L to 3.5 mg/L
  - Guadalupe Reservoir: 1.9 mg/L to 10 mg/L

– Guadalupe Reservoir outlet: 4.5 mg/L to 11.5 mg/L

- **Total mercury.** Total mercury concentrations were somewhat higher in Guadalupe Reservoir compared to Almaden Reservoir as shown below:

  Almaden Reservoir
  - epilimnion 3.54 ng/L to 4.9 ng/L
  - hypolimnion 4.10 ng/L to 19.8 ng/L
  - outlet 7.25 ng/L to 20.8 ng/L, and

  Guadalupe Reservoir
  - epilimnion 11.0 ng/L to 42.8 ng/L
  - hypolimnion 6.5 ng/L to 39.4 ng/L
  - outlet 14.7 ng/L to 49.2 ng/L.

- **Methylmercury.** Methylmercury concentrations were a significant fraction of the total mercury (sometimes more than 20% of total mercury). Methylmercury concentrations were higher in Guadalupe Reservoir as shown below:

  Almaden Reservoir
  - epilimnion 0.34 ng/L to 0.64 ng/L
  - hypolimnion 0.43 ng/L to 5.49 ng/L
  - outlet 2.91ng/L to 7.20 ng/L, and

  Guadalupe Reservoir
  - epilimnion 0.20 ng/L to 0.57 ng/L
  - hypolimnion 0.41 ng/L to 11.5 ng/L
  - outlet 0.85 ng/L to 12.8 ng/L.

- **Mercury in Particulate Fraction.** The total mercury in the particulate fraction from the Almaden Reservoir outlet varied from 1.98 mg/kg to 6.63 mg/kg, compared to 1.60 mg/kg to 3.85 mg/kg from the Guadalupe Reservoir outlet.

Both reservoirs were stratified with respect to temperature and dissolved oxygen beginning in May, as seen in Figure 3-18. Almaden Reservoir stratified sooner than Guadalupe. The dissolved oxygen decreased with depth in the hypolimnion and was less than 1 mg/L at a depth of 25 feet in Guadalupe Reservoir by July and at a depth of less than 35 feet in Almaden Reservoir by June 10th. Between mid to late August, the temperature difference decreased with depth as the reservoir started to turn over. There was still a gradient with respect to dissolved oxygen at the end of August. Guadalupe Reservoir was still stratified with respect to temperature and dissolved oxygen at the end of August. An average depth of 25 feet for the epilimnion was used for the loading analysis in Chapter 4 of this report.

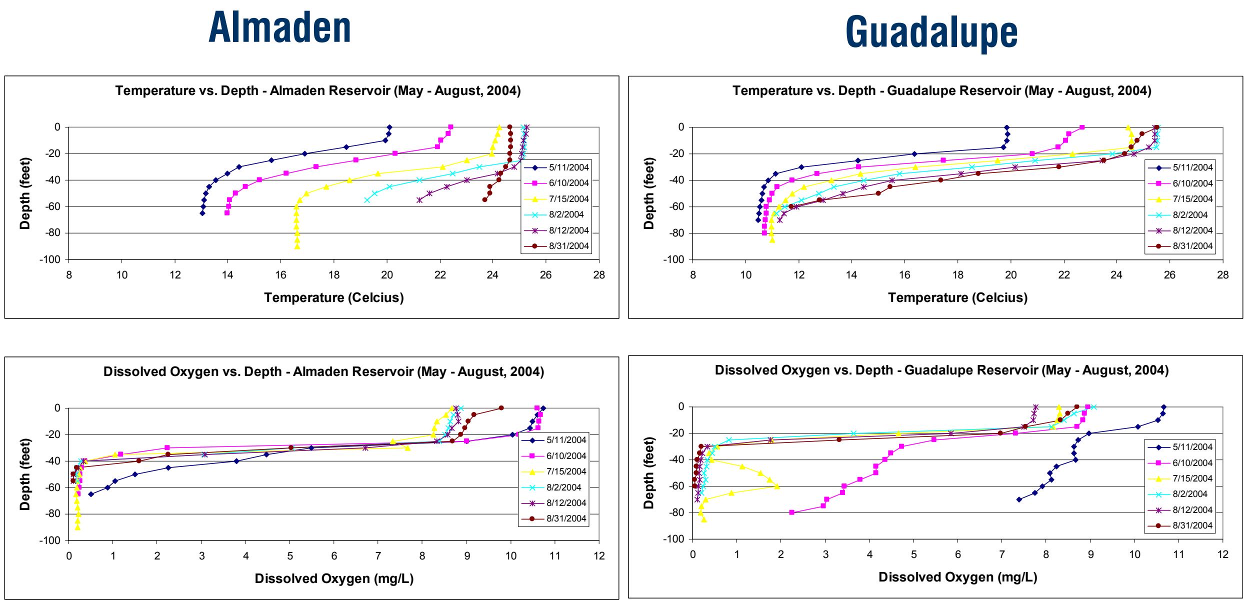
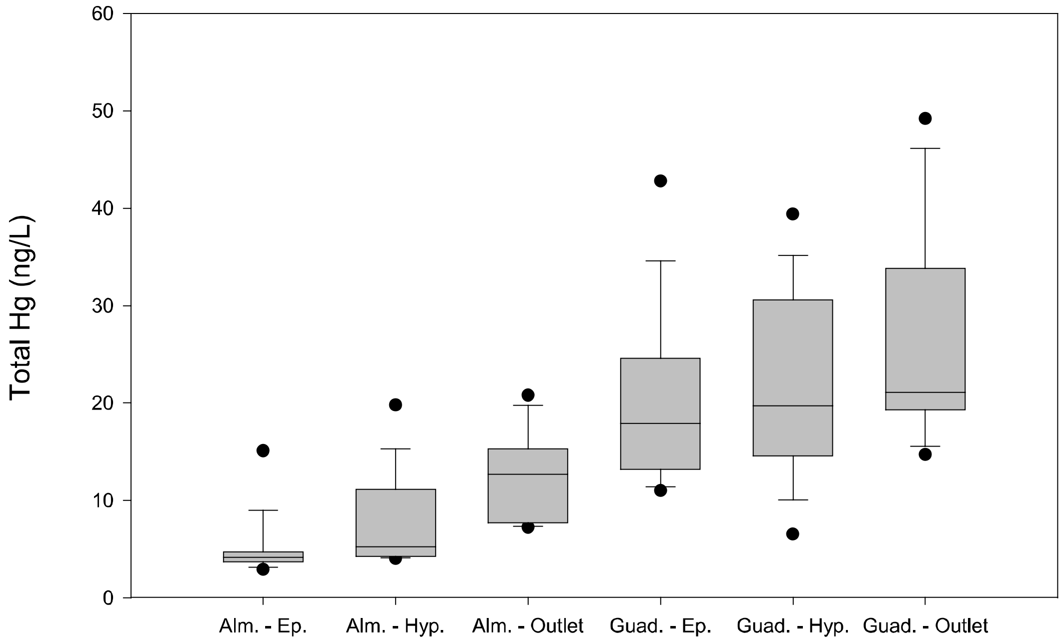


Figure 3-18. Depth Profiles of Temperature and Dissolved Oxygen for Almaden and Guadalupe Reservoirs

3.3.2 Comparison of Mercury Results for Reservoirs

The concentrations of total and methylmercury species and suspended solids in the reservoirs and outlets are compared in Figure 3-19. The mercury and methylmercury concentrations in both reservoirs increased from epilimnion to hypolimnion to the outlets. The highest concentrations of total and dissolved mercury and methylmercury were found in the outlet from Guadalupe Reservoir on August 31, 2004, partly due to the higher suspended solids of 11.5 mg/L. Figure 3-20 shows a clear increase in methylmercury concentrations over the summer in both reservoirs, following the onset of thermal and dissolved oxygen stratification. Methylmercury concentrations were also significantly higher in the late summer than in the wet season when the oxycline is absent or not well-defined in the water column.

Data on total and methylmercury collected during the dry season, 6 times over a fourteen-week period, demonstrated the gradual buildup of methylmercury in Almaden and Guadalupe Reservoirs. Much of the methylmercury generated in the reservoirs was produced in the hypolimnion, which is where the withdrawals for downstream supply take place. The most significant production of methylmercury occurred when the hypolimnion was largely anoxic (dissolved oxygen levels less than 1 mg/l), as expected for microbial transformations by sulfate reducers that require anoxia.



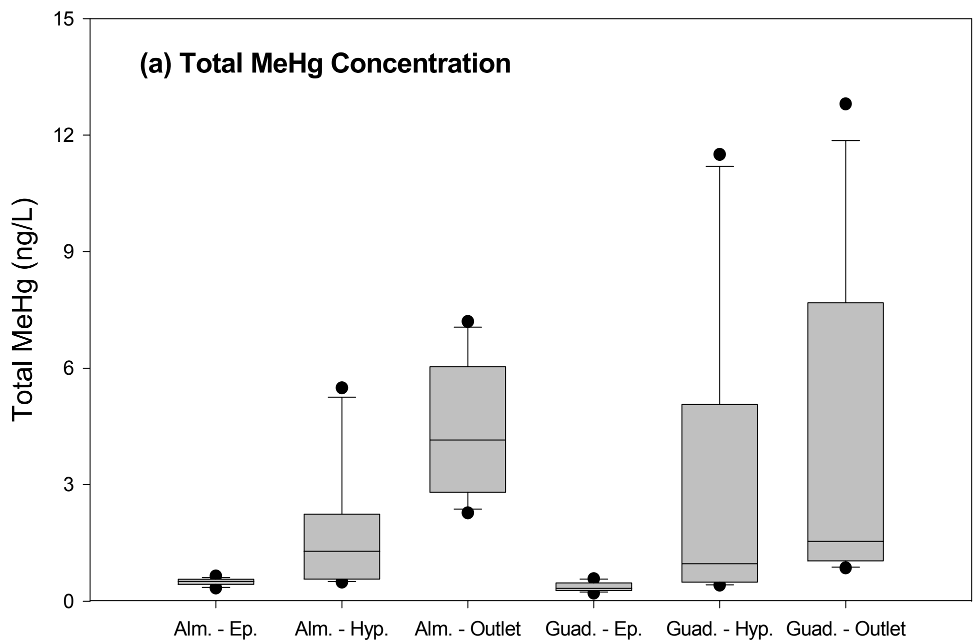


Figure 3-19. Comparison of a) Total Mercury and (b) Total (unfiltered) Methylmercury in Almaden and Guadalupe Reservoirs.

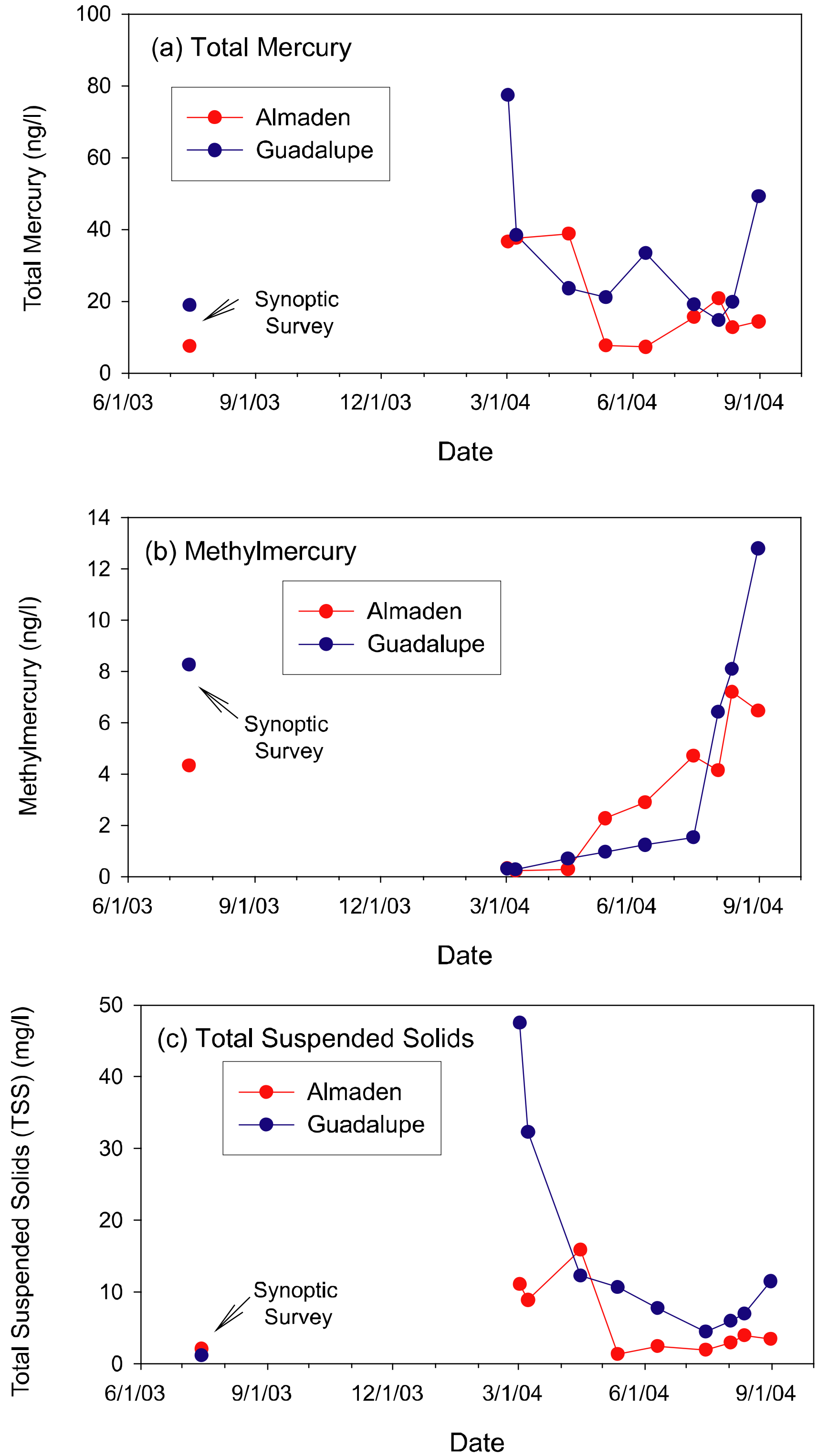


Figure 3-20. (a) Total mercury, (b) methylmercury, and (c) TSS in Almaden and Guadalupe Reservoir Outlets as measured during the Synoptic Survey in 2003 and during the wet and dry season sampling in 2004.

3.4 FISH TISSUE MERCURY DATA

Three sets of fish tissue mercury data exist. The historical fish mercury data consist of 263 measurements in 16 different species of fish collected from multiple locations in the Guadalupe River Watershed. These data were presented in the Guadalupe River Mercury TMDL Workgroup's Recommended Interim Sampling and Monitoring Plan (EOA, 2000). The majority of these data were collected from 1971 – 1987.

Tetra Tech collected largemouth bass (*Micropterus salmoides*) and black crappie (*Pomoxis nigromaculatus*) from Guadalupe Reservoir on May 28, 2003, in conjunction with the U.S. EPA's National Lakes Survey. Tetra Tech collected 15 largemouth bass between 27.3 and 50.5 cm. in total length (TL), and 10 black crappie between 13 and 17 cm. TL. Muscle tissue was collected from each sample for mercury analysis.

A summary of the existing mercury measurements for the most abundant species from these first two data sets is presented in Table 3-5. Because of the differences in size and number of fish at each location, these data are of limited value for making comparisons between locations. However, these data show that the mercury concentrations in fish muscle tissue in the Guadalupe River Watershed exceed the U.S. EPA human health mercury fish criterion (0.3 mg/kg [ppm], U.S. EPA, 2001) at all locations sampled. The historical record shows that mercury concentrations in fish tissue have been very high, and recently collected data, presented below, show that the mercury concentrations remain very high.

Table 3-5
Summary of Fish Mercury Measurements from Guadalupe River Watershed

Location	Sample Size	Avg. Hg (ppm)	Avg. Length (cm)	Avg. Weight (g)
Rainbow Trout				
Alamitos Creek	27	2.9	13.5	108
Guadalupe River	21	1.0	14.4	41.2
Almaden Reservoir	8	0.5	–	–
Guadalupe Reservoir	6	1.3	25	263
Largemouth Bass				
Guadalupe Perc. Pond	21	0.9	14.5	51.2
Guadalupe Reservoir	15	4.0	37.4	700.0
Calero Reservoir	11	2.2	78.6	1179.7
Lexington Reservoir	5	0.7	26.2	436.6
Bluegill				
Guadalupe River, Perc Ponds	19	0.4	–	–
Guadalupe Reservoir	21	2.8	18.6	169.1
Lexington Reservoir	3	0.05	17.3	135.3
Sucker				
Guadalupe Perc. Pond	15	0.6	–	–
Guadalupe River, Highway 17	20	0.4	–	–
Black Crappie				
Calero Reservoir	14	1.3	20.7	164.5
Guadalupe Reservoir	10	1.9	15.5	52.0

In the spring and summer of 2004 an important sampling program was conducted by the USEPA and the Santa Clara Valley Water District to develop new information on the concentration of mercury in fish tissue in the impoundments (Guadalupe Reservoir, Almaden Reservoir, Calero Reservoir, Lexington Reservoir, and Lake Almaden) and creeks throughout the watershed. Adult and age-1 largemouth bass were collected in five impoundments within the watershed. Santa Clara Valley Water District biologists collected samples of the California roach (*Lavinia symmetricus*) at six creek and river locations in the watershed (SCVWD, 2004). These data were collected specifically to establish a baseline to compare changes in fish mercury concentrations over time and in response to mercury source reductions in the water column. A detailed description of the 2004 sampling effort and results is presented in the Data Collection Report (Tetra Tech, 2005a). A summary of these data is presented below, and use of these data in the TMDL is discussed in Section 5.6 of this report.

3.4.1 2004 Adult Largemouth Bass Samples

Total mercury concentrations were measured in muscle tissue samples from adult largemouth bass collected at five impoundments (four reservoirs and Lake Almaden) in the watershed. The results are summarized in Table 3-6. The target sample size was 20 fish from each impoundment, and although fewer samples were collected at Guadalupe (n = 18) and Lexington (n=11) Reservoirs, these large numbers of samples at each impoundment provide an excellent summary of mercury concentrations in large predatory fish (Trophic Level 4) in the watershed. Both the average and range of mercury concentrations exhibit large differences between impoundments. There is an order of magnitude difference in the average total mercury concentrations between Guadalupe Reservoir (6.1 mg/kg wet wt.) and Lexington Reservoir (0.6 mg/kg wet wt.). The coefficients of variation (CV) for the mercury measurements at each impoundment (0.16 – 0.40) are relatively low for environmental measurements. These low CV values indicate the narrow distribution of mercury concentrations in the fish as well as the likelihood of detecting statistically significant differences in mercury concentrations between impoundments.

Table 3-6
Summary of Adult Largemouth Bass Mercury Data

		Total Mercury Concentrations (mg/kg wet)				Total Length (cm)			
Waterbody	Sample Size	Average	Min.	Max.	Coefficient of Variation	Average	Min.	Max.	Coefficient of Variation
Guadalupe Reservoir	18	6.1	3.1	13	0.40	41.8	30.7	53.2	0.18
Almaden Reservoir	20	4.3	2.2	7.4	0.30	43.9	33.8	51.2	0.11
Lake Almaden	20	2.3	1.1	3.8	0.34	41.8	31.2	53.2	0.16
Calero Reservoir	20	1.1	0.8	1.6	0.16	36.7	29.7	47.7	0.12
Lexington Reservoir	11	0.6	0.4	1.0	0.27	40.8	35.8	50.2	0.12

Figure 3-21 presents the average and 95% confidence intervals for total mercury concentration in a 40 cm largemouth bass at the five impoundments sampled. Regression equations were used to calculate the expected mercury concentrations corresponding to a specified (standardized) fish length (Bhattacharyya and Johnson, 1977; Tremblay et al, 1998) to account for the difference in the size of fish collected in the five impoundments. The concentration of mercury in 40 cm largemouth bass exhibits a wide range (0.6 – 5.8 mg/kg) in the waterbodies sampled, and the measured concentrations appear to correlate well with the proximity to the mining district. Because the average total lengths for the adult largemouth bass samples at the five impoundments were similar; the differences between the total mercury concentrations in the fish samples were tested using ANOVA and the SNK multiple comparison tests (Tremblay et al, 1998). The results of these tests indicate the existence of statistically significant differences in the mercury concentrations in adult largemouth bass between all pairs of impoundments, except Calero and Lexington Reservoirs.

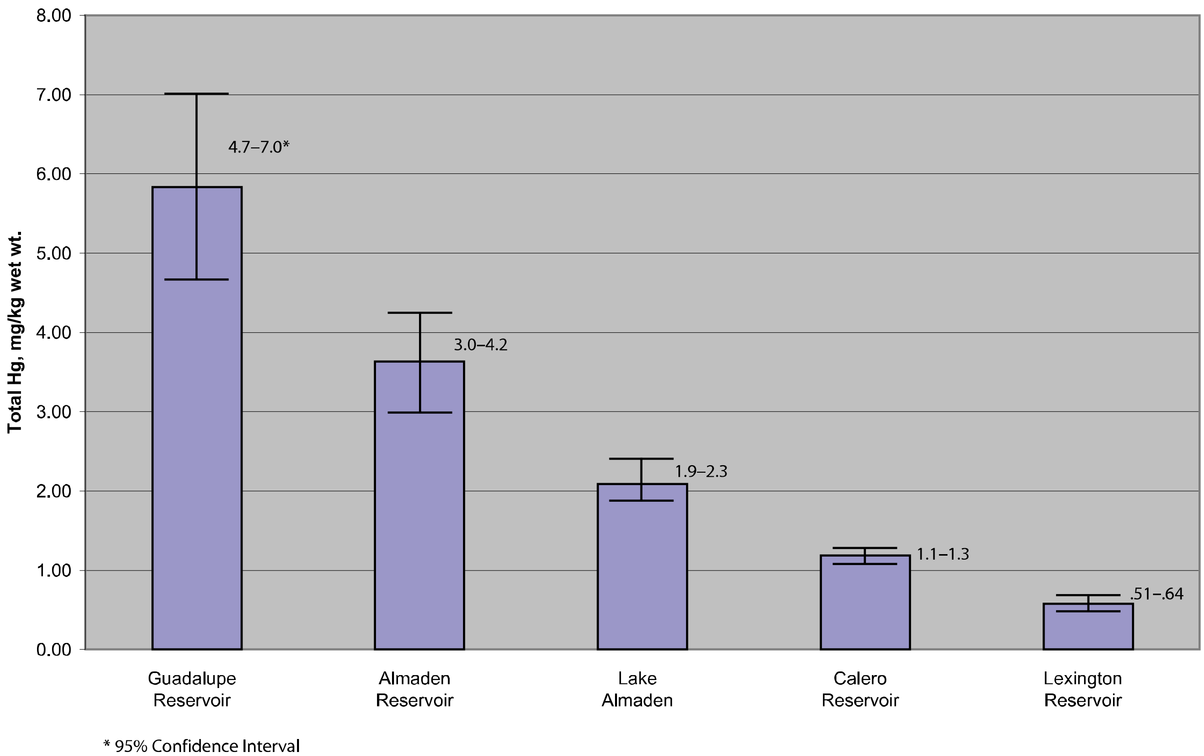


Figure 3-21. Mercury concentrations for standardized 40 cm largemouth bass.

3.4.2 2004 Age-1 Largemouth Bass Samples

Total mercury concentrations were measured in whole-body samples of age-1 largemouth bass collected at the same five impoundments in the Guadalupe Watershed. The results are summarized in Table 3-7. Twenty fish of similar size were obtained from each impoundment, and the variability of the measurements, as indicated by the low coefficients of variation, was low within each impoundment. While the variability of the mercury measurements was low within impoundments, large differences were observed in the fish mercury concentrations between the impoundments. The total mercury concentrations measured ranged from 0.06 mg/kg wet wt at Lexington Reservoir to 1.53 mg/kg wet wt at Almaden Reservoir. All forty samples from Almaden and Guadalupe Reservoirs had mercury tissue concentrations that exceed the U.S. EPA water quality criterion of 0.3 ppm (mg/kg wet wt.). Figure 3-22 presents the average and 95% confidence intervals for total mercury concentrations in an 8 cm largemouth bass at the five impoundments sampled.

Table 3-7.
Summary Of Age-1 Largemouth Bass Mercury Data

		Total Mercury Concentrations (mg/kg wet)				Total Length (cm)			
Waterbody	**Sample Size**	**Average**	**Min.**	**Max.**	**Coefficient of Variation**	**Average**	**Min.**	**Max.**	**Coefficient of Variation**
Guadalupe Reservoir	20	0.83	0.64	1.11	0.17	9.0	7.7	9.7	0.07
Almaden Reservoir	20	0.96	0.58	1.53	0.29	6.9	5.6	8.2	0.10
Lake Almaden	20	0.39	0.21	0.53	0.22	9.3	8.0	10.2	0.08
Calero Reservoir	20	0.21	0.10	0.58	0.53	7.4	5.5	10.2	0.22
Lexington Reservoir	20	0.09	0.06	0.14	0.22	8.9	7.1	10.2	0.10

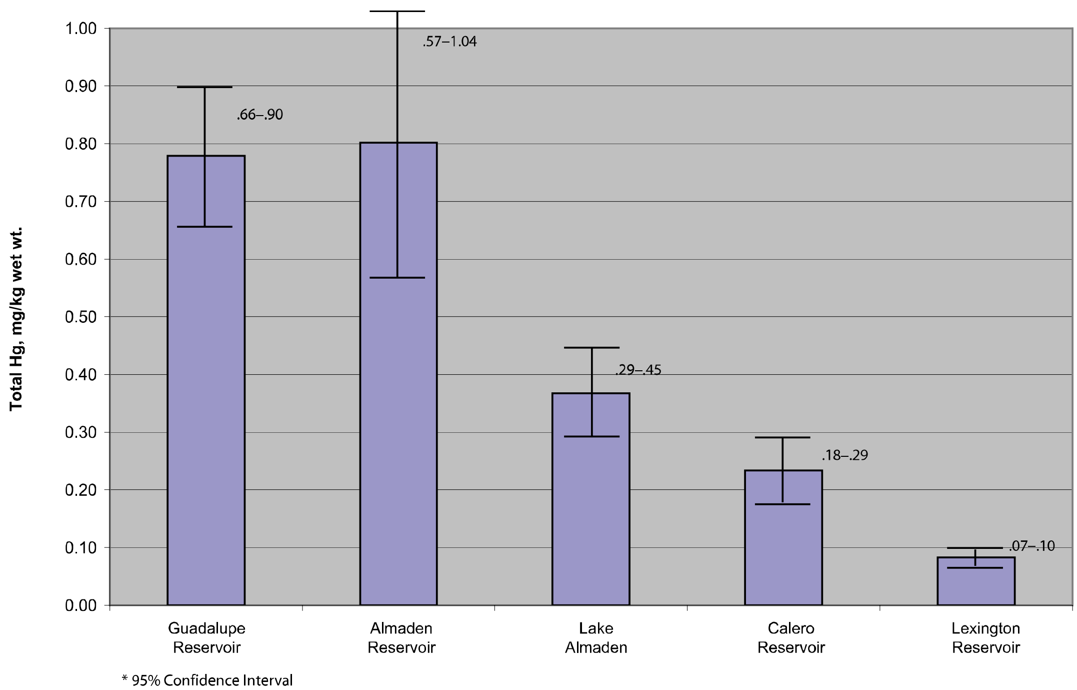


Figure 3-22. Mercury concentrations for standardized 8 cm largemouth bass.

3.4.3 2004 California Roach Samples

Santa Clara Valley Water District biologists collected samples of the California roach (*Lavinia symmetricus*) from six locations in creeks and the Guadalupe River (SCVWD, 2004). Nine locations, representing a wide range of expected aqueous mercury concentrations, were initially selected for sampling (Figure 3-23), but only a few or no roach were present at some of the sampling locations. Whole fish samples, with the gastrointestinal tract removed to prevent contamination with mercury from ingested sediment, were collected to quantify the mercury concentrations in fish species that represent potential prey items to wildlife species.

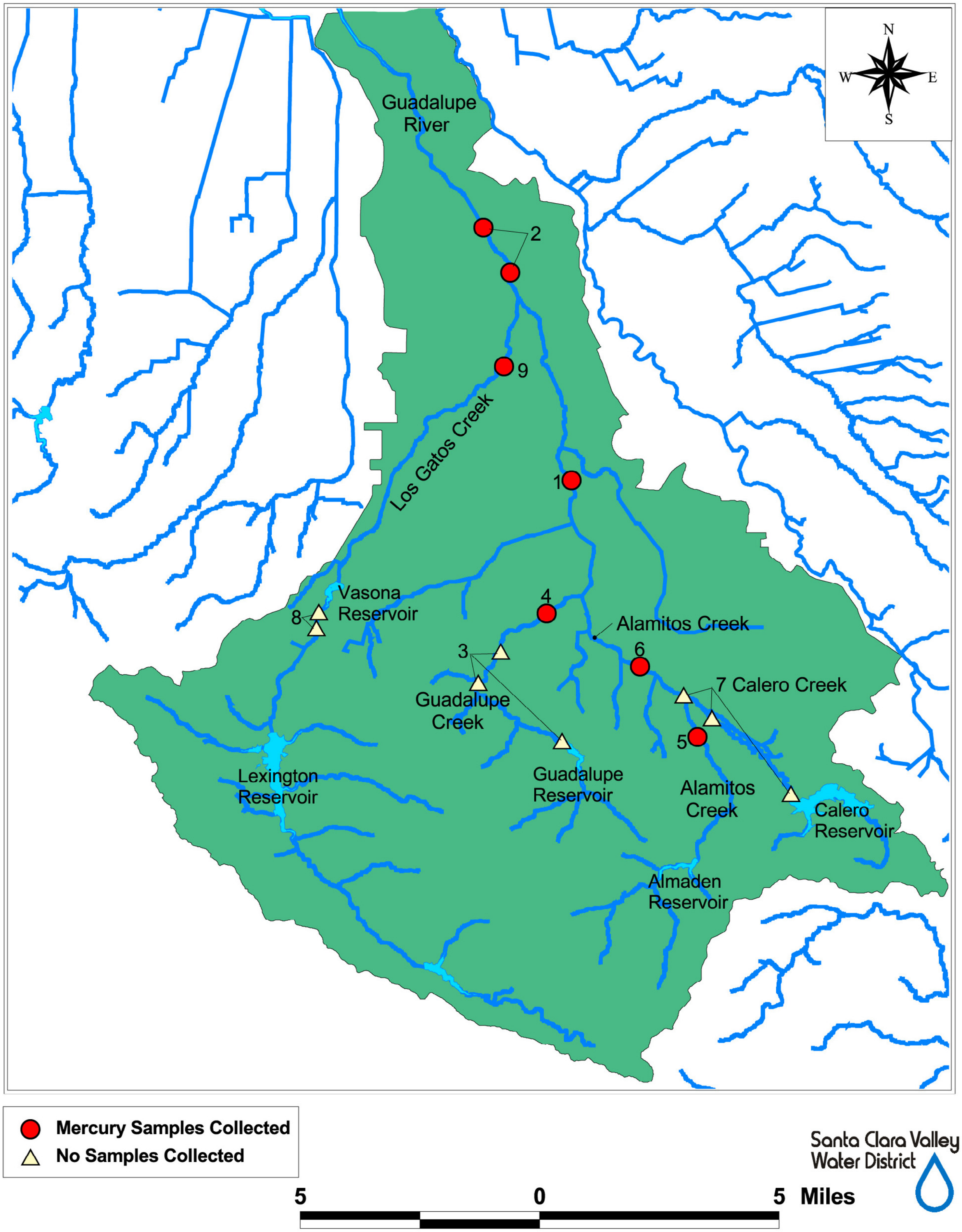


Figure 3-23. Stream sampling sites in the Guadalupe Watershed (SCVWD, 2004).

The results of the California roach sampling effort and the mercury analyses are presented in Table 3-8. All samples were similar in size, between 40 to 55 mm fork length, and based on the examination of scales, age-1 or younger (SCVWD, 2004). The measured mercury concentrations ranged from an average value of 0.03 mg/kg wet wt in Los Gatos Creek (Site 9, Figure 3-23) to an average value of 0.39 mg/kg wet wt on Guadalupe Creek (Site 4, Figure 3-23). Los Gatos Creek is fed by Lexington Reservoir, and the Los Gatos Creek site was selected as a reference to compare non-mining-influenced fish-tissue samples to mining-influenced fish-tissue samples. The Guadalupe Creek sampling site at Meridian Avenue was selected because of its proximity to the mining district and the fact that it is fed by Guadalupe Reservoir. At the Guadalupe Creek sampling site at Meridian Avenue, the mercury concentrations in the tissue of all 20 California roach were greater than the U.S. EPA water quality criterion of 0.3 mg/kg wt wet.

Table 3-8.
Summary of California Roach Mercury Data

			Total Mercury Concentrations (mg/kg wet)			
Site Number	**Waterbody and Location**	**Sample Size**	**Average**	**Min.**	**Max.**	**Coefficient of Variation**
1	Guadalupe R., at Foxworthy Ave.	9	0.15	0.12	0.19	0.17
2	Guadalupe R., at Coleman Ave.	25	0.08	0.04	0.12	0.32
4	Guadalupe Creek, at Meridian Ave.	20	0.39	0.31	0.48	0.11
5	Alamitos Creek, at Harry Road	20	0.28	0.20	0.41	0.21
6	Alamitos Creek, at Greystone Lane	20	0.15	0.10	0.26	0.26
9	Los Gatos Creek, at Lincoln Ave.	20	0.03	0.02	0.04	0.24

ANOVA and SNK multiple range tests were used to examine the statistical significance of observed differences in the average mercury concentrations of these whole-body fish samples between locations (Tremblay et al, 1998). The average mercury concentrations at the Guadalupe River at Foxworthy Avenue and Alamitos Creek at Greystone Avenue (Sites 1 and 6, Figure 3-23) were equal (0.15 mg/kg wet wt), but the differences between the measured mercury concentrations at the other four sites were each significantly different from one another. The range of values at each sampling location and the magnitude of the differences between these locations is shown in the box plots in Figure 3-24. These plots show the 10^{th}, 25^{th}, 50^{th} (median), 75^{th} and 90^{th} percentiles of the fish mercury concentrations. Values above the 90^{th} and below the 10^{th} percentile are plotted as points.

These results clearly demonstrate the ability to quantify the mercury concentrations in fish that are potential prey items to wildlife in the watershed. California roach are omnivores and filamentous algae is the primary staple in their diet, but they can also feed on small insects and crustaceans (Moyle 2002). The California roach are intermediate between Trophic Level 2 (TL2) or TL3 species. The low variability in the mercury concentrations measured at each location, indicated by the small values of the coefficients of variation, suggest that the California roach, like the age-1 largemouth bass, will also make a good biosentinels to detect changes in response to interventions that reduce methylmercury concentrations in the aquatic food web.

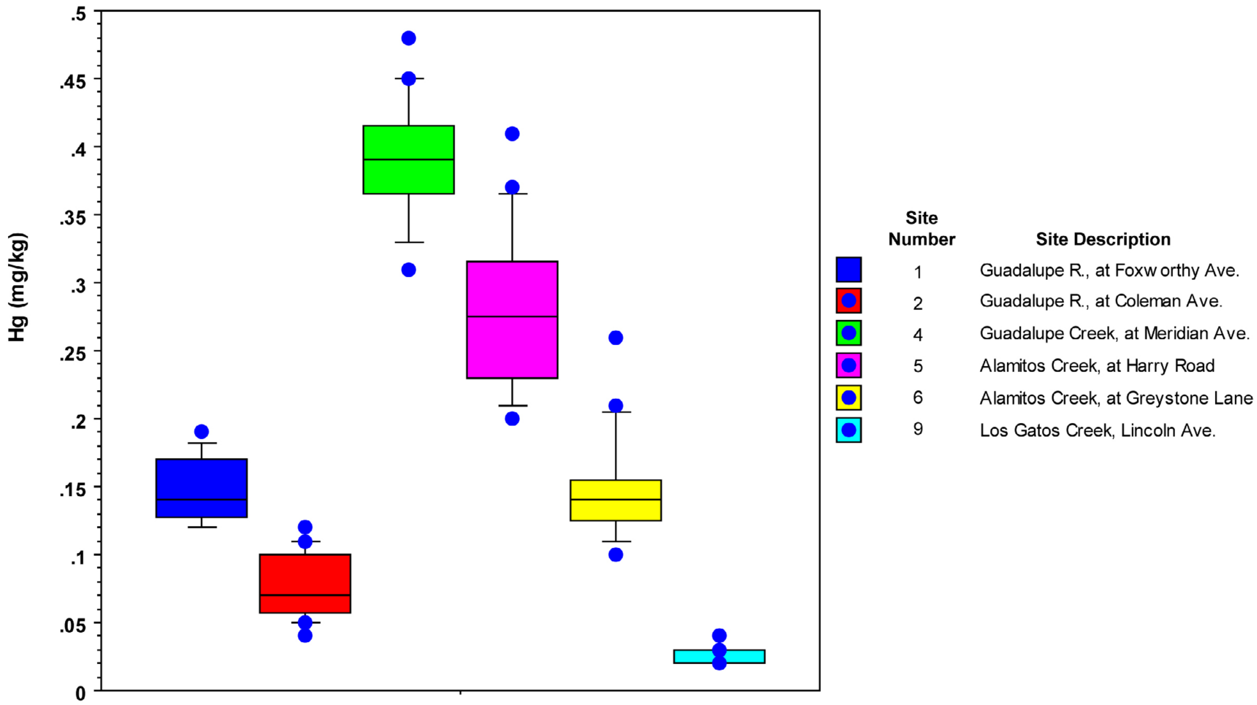


Figure 3-24. Mercury concentration in California roach collected at six sites in the Guadalupe River Watershed. (see Figure 3-23 for location of sampling sites)

3.4.4 Summary of Bioaccumulation Data

A summary of the 2004 fish sampling results is shown on a schematic diagram of the Guadalupe River Watershed in Figure 3-25. The range of measured concentrations of mercury in the fish tissue is shown for each sampling location. The shading of the fish symbols indicates the relative magnitude of the concentrations measured. For example, the maximum concentrations of mercury in adult largemouth bass were measured at Guadalupe Reservoir, where the range of values was 3.1 to 13.0 mg/kg wet wt. The lowest mercury concentrations in both the adult and age-1 largemouth bass were measured at Lexington Reservoir, where the ranges of mercury values were 0.4 – 1.0 mg/kg wet wt for adults and 0.06 – 0.14 mg/kg wet wt for age-1 fish. The stream sampling sites, where the California roach tissue samples were collected, are also shown on the watershed schematic. The highest concentrations in the whole-body California roach samples were measured at Guadalupe Creek sampling site (Site 4), where the range of mercury concentrations was 0.31 – 0.48 mg/kg wet wt. The lowest concentrations in the California roach were measured on Los Gatos Creek (Site 9), where the ranges of values was 0.02 to 0.04 mg/kg wet wt.

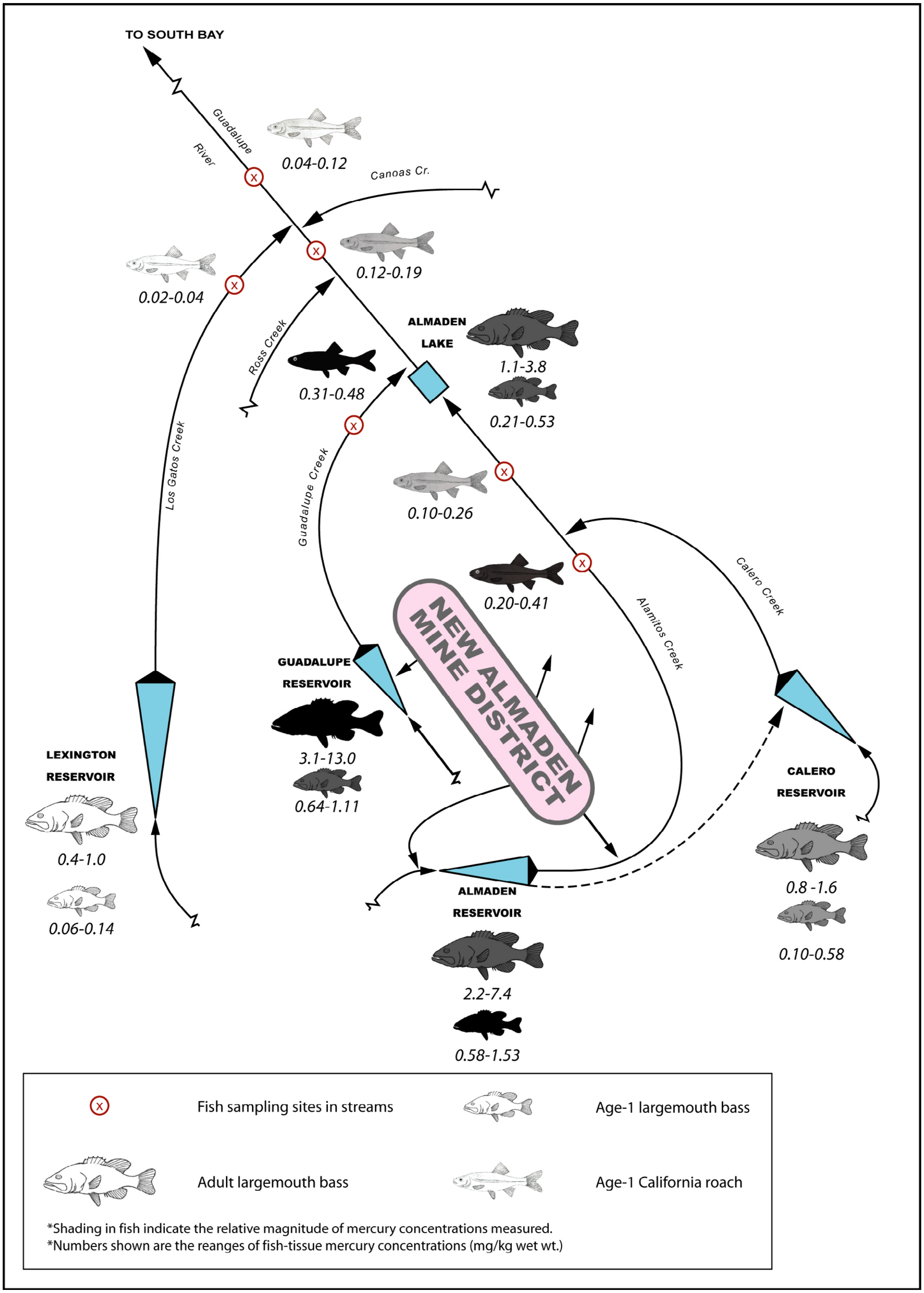


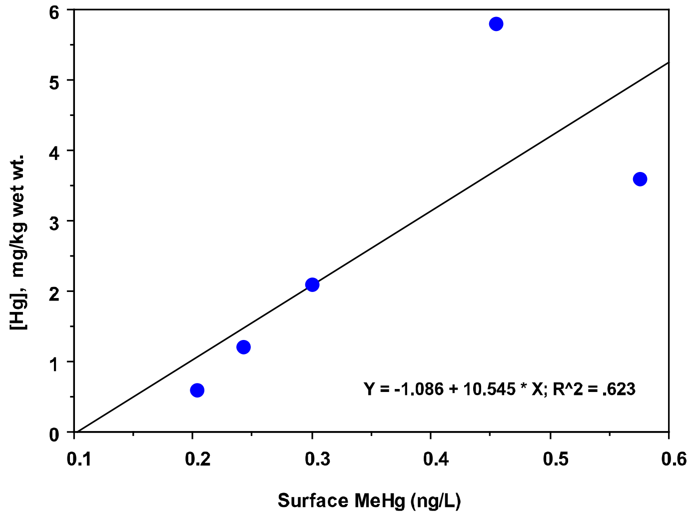
Figure 3-25. Summary of 2004 fish sampling results.

The differences in the fish tissue mercury concentrations exhibited in Figure 3-25 were examined further to determine if a linkage could be established between fish tissue concentrations and aqueous mercury concentrations. Table 3-9 presents measurements of total mercury concentrations in adult largemouth bass at the five locations sampled and unfiltered aqueous methylmercury concentrations in the surface and hypolimnion of the impoundments. The fish tissue concentrations are the average total mercury measurements for a 40 cm adult largemouth bass. The water concentrations in Table 3-9 are averages of measurements at Almaden and Guadalupe Reservoirs on one date in July 2003 and six dates between May 11 and August 31, 2004. These measurements were taken at both the surface and at the reservoir outlet (referred to in the table as the hypolimnetic samples since water is released from the bottom of the reservoirs below the thermocline). The July 2003 samples were collected for the Synoptic Survey (Tetra Tech, 2003d), while 2004 samples were collected during the 2004 dry season sampling conducted as part of the Data Collection Program (Tetra Tech, 2005a). The mercury concentrations at Almaden and Guadalupe Reservoirs are well characterized. A single value is used for the surface-water methylmercury concentration at Lake Almaden. This value is the average of two samples collected at the outlet in April 2004 as part of the Wet Weather Sampling under Part 1 of the Data Collection Plan (Tetra Tech, 2005a). There is no measurement for the hypolimnion at Lake Almaden. The surface-water and hypolimnion values for Calero and Lexington Reservoirs are from samples collected on one date in July 2003.

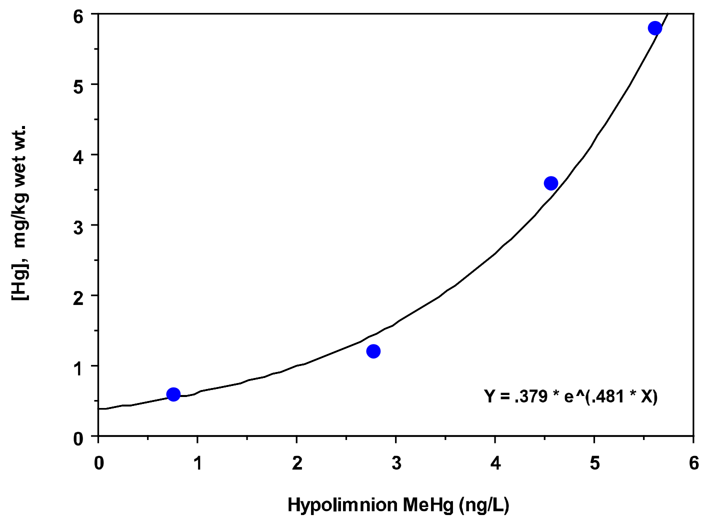
Table 3-9.
Paired Mercury Measurements In Adult Largemouth Bass And Impoundment Water Samples.

		MeHg, ng/l unfiltered		Log(BAF, L kg-1)	
Waterbody	**Average Fish Tissue Total Hg *mg/kg wet***	**Surface**	**Hypolimnion**	**Surface**	**Hypolimnion**
Guadalupe Reservoir	5.80	0.46	5.61	7.1	6.0
Almaden Reservoir	3.60	0.58	4.57	6.8	5.9
Lake Almaden	2.10	0.30	-	6.8	-
Calero Reservoir	1.20	0.24	2.77	6.7	5.6
Lexington Reservoir	0.60	0.20	0.76	6.5	5.9

The relationship between the mercury concentration in the adult largemouth bass and the water samples is shown in Figure 3-26. Fish mercury concentrations are positively correlated with the methylmercury concentrations measured in both the surface water and the hypolimnion. The exponential relationship between the methylmercury concentration in the hypolimnion and the mercury concentration in the adult largemouth bass may be related to the fact that the average methylmercury concentrations in Guadalupe and Almaden Reservoirs used in the regression analysis underestimate methylmercury production in the systems. The average values were calculated using measurements collected throughout the period of reservoir stratification, but methymercury production rates increase with time (and oxygen depletion) during the summer stratification period. Conversely, mercury methylation may not increase significantly or as rapidly during the summer stratification period in an uncontaminated waterbody like Lexington Reservoir.



(A)



(B)

Figure 3-26. Relationship between mercury concentrations in adult largemouth bass and methylmercury concentrations in surface (A) and hypolimnetic (B) waters samples.

The log transformed values of the bioaccumulation factors (BAFs) are also shown in Table 3-9. The BAF is the ratio of the tissue concentration to the water column concentration of mercury in units of L kg-1:

$$BAF = CT/CW * 10^6$$

where:

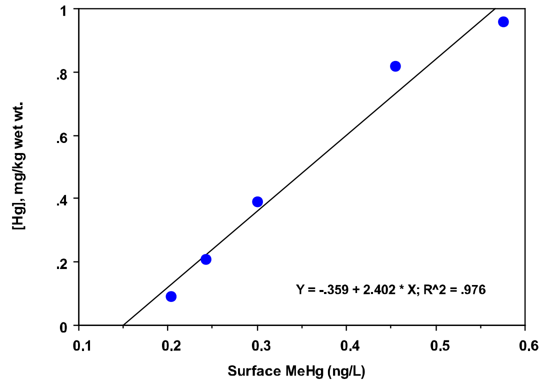
CT = MeHg concentration in the fish tissue, mg/kg
CW= MeHg concentration in the water, ng/L

These log-transformed values correspond and are within the expected range of bioaccumulation factors for large piscivorous fish.

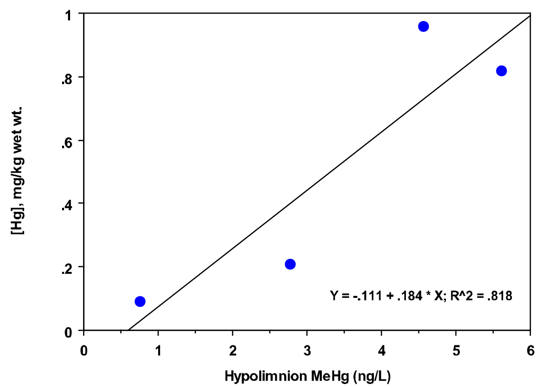
Table 3-10 presents paired measurements of total mercury in the age-1 largemouth bass (Trophic Level 2) and unfiltered methylmercury in the surface and hypolimnion of the impoundments in the Guadalupe Watershed. The fish tissue concentrations are the values calculated for an 8 cm age-1 largemouth bass. The water concentrations in Table 3-10 are the same concentrations that were presented in Table 3-9. As shown in Figure 3-27, the paired concentrations are positively correlated. The fit of the data is expecially good for the relationship between the surface-water methylmuercury concentration and the concentration of mercury in the age-1 largemouth bass ($r^2 = 0.98$).

Table 3-10.
Paired Mercury Measurements In Age-1 Largemouth Bass And Impoundment Water Samples.

		MeHg, ng/l unfiltered		Log(BAF, L kg-1)	
Waterbody	**Average Fish Tissue Total Hg *mg/kg wet***	**Surface**	**Hypolimnion**	**Surface**	**Hypolimnion**
Guadalupe Reservoir	0.82	0.46	5.61	6.3	5.2
Almaden Reservoir	0.96	0.58	4.57	6.2	5.3
Lake Almaden	0.39	0.30	-	6.1	-
Calero Reservoir	0.21	0.24	2.77	5.9	4.9
Lexington Reservoir	0.09	0.20	0.76	5.6	5.1



(A)



(B)

Figure 3-27. Relationship between mercury concentrations in average age-1 largemouth bass and methylmercury concentrations in surface (A) and hypolimnetic (B) waters samples.

A summary of mercury concentrations measured in California roach (Trophic Level 2-3) and surface water at the six locations sampled by the SCVWD in 2004 is presented in Table 3-11. The fish tissue concentrations are the average total mercury concentrations. The water samples were collected at five sites near the fish sampling locations in July 2003 as part of the Synoptic Survey (Tetra Tech, 2003d). Most water samples were collected at or close to the fish sampling locations. The calculated BAF values are consistent with observations in other systems where methylmercury is taken-up rapidly in the water column by algae and transferred by ingestion to zooplankton and planktivorous fish. The concentration of methylmercury in the California roach is approximately 300,000 to 600,000 times the methylmercury levels in the water column. A strong positive relationship is exhibited between the unfiltered methylmercury concentrations in the streams and Guadalupe River and the measurements of mercury in the fish tissue (Figure 3-28).

Table 3-11.
Summary of Stream Sampling Mercury Data

Site	Waterbody	Fish Total Hg mg/kg wet	Total Hg, ng/l unfiltered	Me Hg, ng/l unfiltered	Log(BAF) (L kg^{-1})
1	Guadalupe R., Foxworthy	0.15	105	0.323	5.66
2	Guadalupe R., Coleman Ave.	0.08	-	-	-
4	Guadalupe Crk, Meridian Ave.	0.39	38.9	0.990	5.60
5	Alamitos Crk, Harry Road	0.28	503.2	0.886	5.50
6	Alamitos Crk, Greystone	0.15	25.88	0.306	5.68
9	Los Gatos Crk, Lincoln	0.03	3.2	0.037	5.83

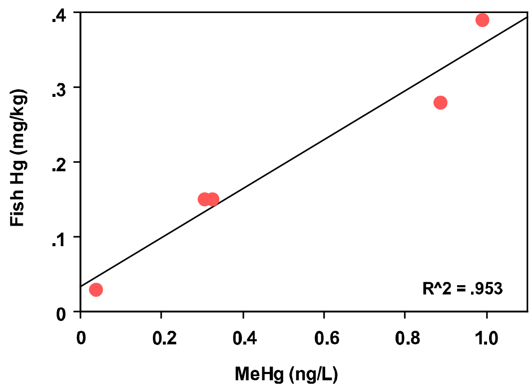


Figure 3-28. Relationship between mercury concentrations in California roach and unfiltered methylmercury concentrations in water samples.

The fish sampling program conducted in 2004 builds on the historical data and combines the results from several field and laboratory efforts where different species, size ranges, and locations were sampled. The results of the fish sampling and measurements of mercury in tissue samples provides valuable new information to support the use of fish tissue as a numeric target for the TMDL. Fish tissue mercury concentrations have been shown to be elevated within the watershed, and the reported concentrations represent a potential risk to human consumption and wildlife predators. A baseline for fish mercury concentrations in the watershed has been established. Age-1 largemouth bass and California roach have been shown to be sensitive biosentinels that can be used to monitor recovery in the streams and impoundments of the watershed. This information is combined with other mercury measurements in the watershed in Section 5.6 to assess the feasibility of developing an aqueous methylmercury target in addition to a fish-tissue target for this TMDL.